BIOLOGY

PART III

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PART III

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FOREWORD

THE first edition of Biology Part III was published in 1969. It was based largely on the pattern of materials used in schools of USSR where science is taught as separate disciplines from the middle stage. This edition has been revised, taking into account the revised syllabus and feedback received from teachers. The first two chapters "Mammals" and "Classification of Animals" have been transferred to Part II of the series, thus making this a complete book on human physiology. Care has been taken to improve some of the illustrations.

This book, like others in the series, emphasizes the conceptual understanding and reasoning rather than retention and reproduction of facts. The curriculum on the basis of which this book has been written has a practical bias and the student is made to gain knowledge through experiments conducted by teachers and pupils.

This book will now be taught in selected schools under the pilot project for improvement of science education in schools. On the basis of the feedback and suggestions received further improvements would be made in future editions.

The first textual materials for this book were developed by a team of writers consisting of Sarvashri S. Doraiswami, G. Raju, S. P. Sharma and K. B. Gupta. They had the benefit of the advice of the UNESCO Consultants, Dr. V. M. Galushin and Dr. V. I. Galakhov. The revision of this edition has been mainly done by Sarvashri S. Doraiswami, G. Raiu, S. P. Sharma and the UNESCO Consultant, Dr. V. I. Galakhov. Our grateful thanks are due to all of them and other members of the Biology Group of our Department of Science Education.

Suggestions for the improvement of the book are welcome and would be gratefully acknowledged.

New Delhi
March 1972

S. V. C. AIYA
Director

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CHAPTER I

Introduction to Human Physiology

Anatomy and Physiology

Anatomy and physiology are some of the branches of the studies of living organisms and as such are aspects of biological sciences. Human anatomy is the study of the external and the internal structure of the human body. Human physiology is the study of the functions of the human body; of the life activities of the organs and the organism as a whole.

Physiology: its Relation to Anatomy and Hygiene

Anatomy, physiology and hygiene are connected subjects. In order to understand the functions or works of the organs it is necessary to understand their structure. Likewise to understand the structure of the organs of the body, it is necessary to have a correct understanding of their functions.

The relationship between the structure of an organ and its functions is so great that a change in the function of an organ results in change of its structure. In the same way any change in the structure of an organ involves a corresponding change in the function. For example, a person who does physical exercises regularly, makes certain groups of muscles in his body work intensively. The muscles increase in size and become stronger and firmer. On the other hand, muscles that are not exercised diminish in size and gradually lose their normal structure. The maintenance of a healthy body depends upon the development of a strong structure of the parts of the body and their efficient working.

Largely dependent on human physiology is hygiene–the science of health. Hygiene is concerned with the study of influence on the human body of the conditions in which man lives and determines the criteria of proper nourishment, rest and sleep. The solution of the problems in hygiene largely depends on the achievements in anatomy and physiology.

Importance of the Knowledge of Anatomy, Physiology and Hygiene of Human Body.

Without a knowledge of anatomy and physiology it is impossible to have a correct understanding of man's place in nature, his relationship to animals and his origin and development. By proving the fact that man and animals had the same origin, people can be helped to free themselves from superstitions and prejudices.

The subjects, anatomy and physiology of human body came into existence and developed as a result of the practical needs of man. In order to cure a person of a disease and prevent its incidence, it is necessary to have a correct understanding of the structure of the human body and the processes going on in it.

Without a knowledge of anatomy and physiology a surgeon would not be able to perform any operation, some of which are highly complicated. A study of the structure of various organs of the human body and their functions led to the correct understanding and treatment of many diseases which were formerly considered incurable. The discovery of the role of Vitamins and their nature has led to the discovery of certain new methods of treating and curing serious diseases likes scurvy, rickets, etc. The successful application of blood transfusion which has saved the lives of many a patient, has become possible as a result of the study of the properties of blood.

An intensive study of the physiology of the human body has led to finding out methods of control and prevention of contagious diseases. The rules of healthy living have been formed on the basis of knowledge of anatomy and physiology. A study of the structure and functions of his body enables man to adopt hygienic habits. Very often people do not have a clear idea of the needs of their body. They are unaware of how the various factors (light, temperature and sports) influence the development and functions of their body. This ignorance results in many physical defects (short-sightedness, stoop, etc.) and illness (for instance heart troubles) which could be avoided. Ignorance about teeth and their structure leads to their decay.

Some school children, for instance are short-sighted. Usually these are the children who are industrious and fond of reading. Very often they replace a walk or other out-of-door activities by reading books. Often they read at dusk with little light and not infrequently lying on a bed. All this demands

an additional effort by the eye and results in shortsightedness. Whenever there is change of weather, some children fall ill. Their bodies are too sensitive and are subjected to illness resulting from cold. Some school children neglect personal hygiene: they drink from the glasses used by their friends and this helps the spread of infectitious diseases like diphtheria, tuberculosis.

The knowledge of anatomy, physiology and hygiene helps man to develop a correct attitude to the various factors influencing his development and health.

Summary

Anatomy is the study of internal structure and physiology the study of the functions of our body. The structure of any part of our body and its functions are inter-related to one another. Hygiene is the science of health. For healthy living, knowledge of the structure of our body is very essential. The study of hygiene helps us to prevent some of our bodily defects and certain illnesses.

Questions

1. Define: (i) anatomy (ii) physiology and (iii) hygiene.
2. How does the knowledge of anatomy, physiology and hygiene of our body help us?

General Survey of the Human Body

Parts of an Animal Cell

The animal cells very much resemble the plant cells. An animal cell like a plant cell has a nucleus which is a compact spherical body seen prominently inside the cell. The nucleus of a cell functions in two important ways. It controls and regulates the activity of the cell as a whole. It plays an important role in the division of a cell. The nucleus is in the midst of cytoplasm. In the cytoplasm many non-living substances generally known as inclusions are present. The cytoplasm may also contain small vacuoles.

In what respects are the animal cells different from plant cells? You have learnt that the plant cells are covered with cell walls. But all animal cells have only a covering of a very thin membrane called the cell membrane which acts as a protective covering of the inner parts of the cell. It also regulates the passage of material in and out of the cell. Animal cells have no cell walls.

A large granule called centriole lies close to the nucleus. This is not found in plant cells. You have seen that plant cells have plastids in them. In animal cells they are absent.

Chromosomes

The nucleus is the vital part of a cell. When a cell is not in dividing stages, a net-work of certain minute granules are seen inside the nucleus. The granules are the chromatin granules. When a cell is about to divide the net-work becomes thicker. At a later stage thick, rod-like bodies called *chromosomes* appear. The chromosomes contain the material that control the hereditary characters of an organism. The number of chromosomes in an organism is often constant. The cells of the human body contain 23 pairs of chromosomes (Fig. 2.1). The cell contains organic compounds: proteins, fats and carbohydrates.

Functions of the Cells

Living cell takes in nutrients respires, grows and excretes the waste products. This is one of the manifestations of their vital activity.

Other important manifestations of the living cells are irritability and reproduction. Irritability is the ability of the cells to respond to a change in the surrounding medium by various changes in their living functions. Reproduction of the cells is achieved through division.

Fig. 2.1 Chromosomes of man

Tissues

The human body is made up of many billions of cells. It will not be useful if all the cells composing our body were of the same type. Therefore, groups of cells are organized for carrying out certain specific functions. Each of these groups of similar cells is called a tissue. The tissues of the human body may be classified into four groups based on the structure of the cells and the functions they perform. They are, epithelial, connective, muscular and nervous tissues.

Epithelial Tissues

Epithelial tissue covers and lines all the outer and inner surfaces of the body. It forms the outer layer of skin and performs defence functions. The epithelium of the skin consists of several layers of cells (Fig. 2.2). A single layer of

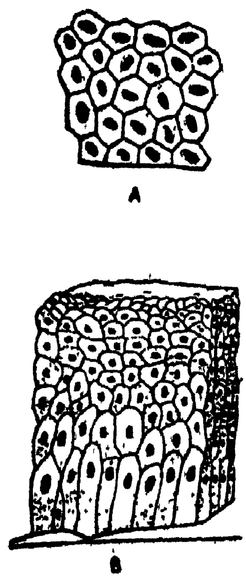


Fig. 2.2 Epithelial tissue of Skin. A. Surface view; B. Section

epithelial tissue lines the abdominal

and thoracic cavities and covers the outside surface of all the internal organs like the stomach, lungs, heart and kidney. The smooth membrane which covers the mouth cavity, the wind pipe, oesophagus, stomach, intestine and other organs consists of epithelial tissue. This membrane is known as the mucous membrane. Some of the cells of the membrane produce and secrete mucous, from which the membrane gets its name. These epithelial cells have thus secretory functions.

Connective Tissue

The main function of the connective tissue is to connect one tissue or groups of tissues to another. It enters into the composition of almost all the organs of the body. The layer of connective tissue in the skin provides for the elasticity of the skin. The tendons of the muscles and the ligaments which hold the bones of the skeleton together are made up of connective tissue. Cartilage and bone are also greatly changed forms of connective tissue. The cells of connective tissue are not in contact with one another. They are immersed in the intercellular substance which compose the chief mass of the tissues.

Blood is sometimes classified as a connective tissue.

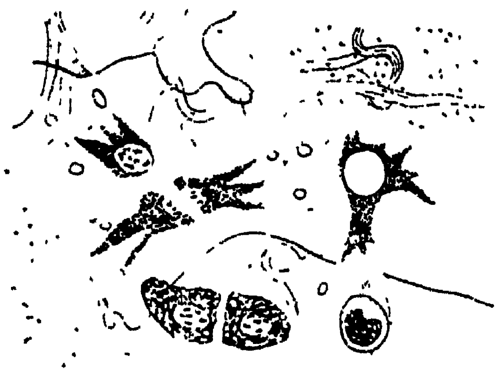


Fig. 2.3 Connective tissue

Muscular Tissue

Muscular tissue is the prominent tissue of the body. It comprises more than one third of the weight of the body. The muscular tissue includes not only the muscles which are attached to the bones and move the body, but muscle layers of the internal organs, the walls of blood vessels and the walls of the heart.

Muscular tissue is classified into three types according to the types of cells that compose it. They are striated or skeletal muscle; smooth muscle and cardiac muscle.

The muscles that are attached to the skeleton are called skeletal muscles. Its structure can be very easily observed if you examine a piece of well-boiled meat. Individual muscular fibres are cylindrical in form. The cells of these muscles show characteristic markings. Because of the presence of these hori-

zontal markings or striations, they are known as striated muscles (Fig. 2.4). These muscles are all very large and active. They require several centres to regulate their activities. Hence it is very common to find each striated muscle cells containing many nuclei. These nuclei lie in the protoplasm outside the main body of the cells but surrounded by a very thin membrane. The striated muscles contract at our will. They are therefore often called **voluntary muscles.**

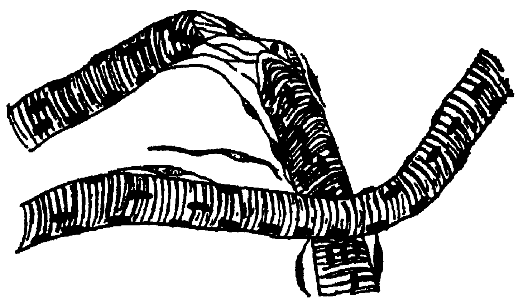


Fig. 2.4 Striated muscles

Smooth muscular tissue is found in internal organs. It consists of spindle-shaped fibres (Fig. 2.5). Smooth muscular tissue contracts much slower than the striated muscular tissue. It is not controlled by the nervous system and therefore is called **involuntary muscle.**

The heart is composed of the

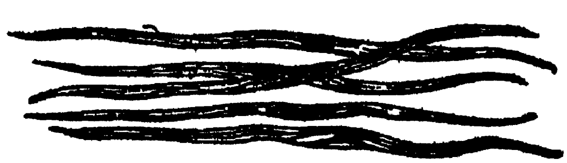


Fig. 2.5 Smooth muscles

cardiac muscles (Fig. 2.6). The cells of the cardiac muscles are greatly branched and joined so as to form a protoplasmic network. Each cell has only one nucleus and shows very faint striations.

Fig. 2.6 Cardiac muscles

Nervous Tissues

Nervous tissue is formed of nerve cells, the **neurons.** Under a microscope it is seen that each neuron consists of the body cell and the processes as shown in Fig. 2.7.

The following experiment can help to clarify the properties of the nervous tissue. From a frog's body cut out the thigh muscle together with the nerve entering it. Apply electric current to the nerve or pinch it with a forceps. You will see the muscle contracting. When the nervous tissue is irritated there develops process of irritation. This irritation is conducted through

fibres of the nerves to one or another organ, for instance, to a muscle which contracts. Excitability and conductivity are the properties of the nervous tissue.

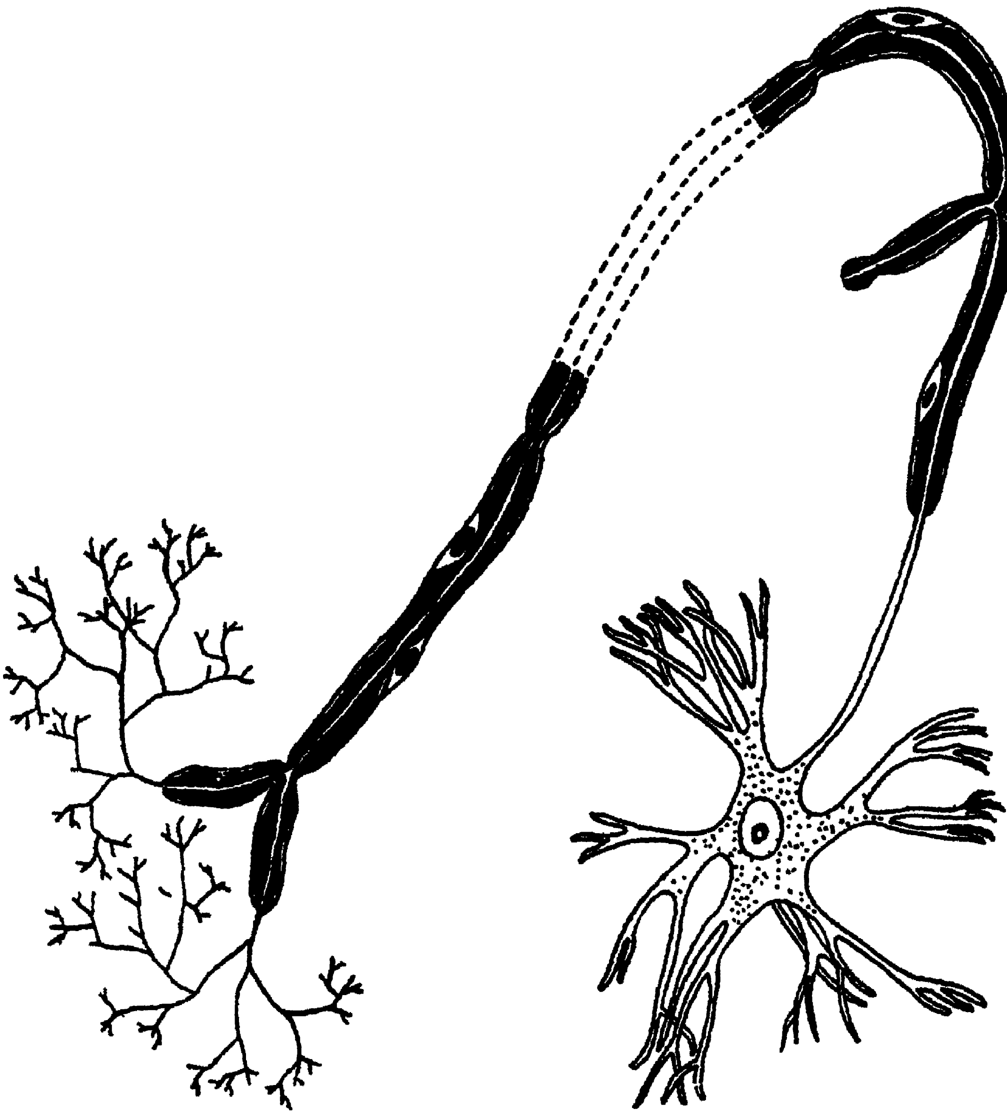


Fig. 2.7 Nerve cell

Organs and Organ Systems

Different kinds of tissues are often combined to function in a united manner. Such a group of tissues is an organ. The tissues of an organ may have different structures and functions. But the organ

is often specialised to do some vital activity.

The hand may be taken as a example of an organ. The hand is made up of many different kinds of tissues. The outside of the hand is covered by the epithelial tissue. The hand and the fingers are moved by the action of striated muscles of which there are many bundles arranged inside the hand. Bone and cartilage form the supporting frame-work of the hand. Food and oxygen are distributed to the tissues of the hand through the blood vessels. The hand is supplied with the nerves. All these tissues are bound together by connective tissue. Thus the hand, though it is composed of different kinds of tissues, functions as a unit. An organ is a more efficient functioning unit than a single tissue, since it combines the activities of different kinds of tissues. Other example of organs are heart, lungs, brain, eye, liver, stomach and kidney.

An organ like the hand is able to carry out efficiently certain functions. But certain organs work in relation to certain other organs. The stomach for example is an organ. But the stomach will not be able to digest the food all by itself. It requires the combined activity of the mouth oesophagus, stomach, small intestine, liver and and pancreas. It requires the help of the large intestine in absorbing water and eliminating the undigested food materials. All these organs work as a team in digesting the food and eliminating the undigested materials.

Organ System

When several organs are grouped together and they function together in carrying out some major body activity, it is referred to as the organ system. There are at least nine major organ systems in our body. They are the skeletal, muscular, digestive, circulatory, respiratory, excretory, nervous, reproductive and endocrine systems.

Skeletal System

The skeletal system forms the framework of the human body. It is made up of a large number of bones and connective tissues that hold bones together. These bones are not attached rigidly, but are connected by joints that allow movement.

Muscular System

The bones that constitute the skeletal system can move only when they are pulled. This work of pulling the bones is done by the muscular tissues. The muscular tissues are tough tissues and are arranged

as sheets and bundles of muscles. This system not only moves the head, neck, arms, trunk and legs but makes the blood circulate in our body and push the food through the food canal. All the movements in our body are performed by the muscular system.

Digestive System

Any movement of the body or its parts requires energy. Energy is needed for all sorts of work in our body. This energy comes to us from the food we eat. Though the energy is locked up in the food we eat it may not be possible for the body to utilize the energy from the food. For this the food must be made simpler. The digestive system helps to break down the food so that it can be absorbed into the body.

Respiratory System

Oxygen is needed to release the energy contained in the nutritive materials. Oxygen, as you know, is present in the air around us. The body has a special system called the respiratory system which includes the organs like the nose, wind-pipe, bronchial tubes and lungs. The respiratory system supplies air to the body. From the air supplied, oxygen is separated out and utilized for liberation of energy. The respiratory system also helps in collecting carbon dioxide and sending it out of the body.

Circulatory System

The nutritive substances absorbed from the food by the body and the oxygen extracted from the air should be circulated throughout the body. These substances are required by all the cells in the body. The circulation of these substances is done by the blood stream. The blood moves through certain tubes called blood vessels. The movement of the blood is caused by the ever pumping organ, the heart. The blood vessels, the heart and the blood constitute the circulatory system.

Excretory System

As the body goes on working, certain waste products are formed inside it. These products are to be thrown out of the body. The kidneys extract these waste products from the body and send them into the bladder as urine. The kidneys, ureters and the urinary bladder form the excretory system. The removal of waste products are done by certain other organs also. For example, the skin sends out some waste products as sweat and the lungs help to eliminate carbon dioxide.

Nervous System

We have seen that different organs are assembled and work as organ systems. The organs and the organ systems do various kinds of work because they have been signalled to do so by the brain. The brain, the spinal cord and the nerves constitute the nervous system. The nervous system coordinates the activities of different organs of our body and connect us with the surrounding medium through the sense organs.

Endocrine System

Actually there are two coordinating systems in our body. One is the nervous system. The other system coordinates the working of various organs and the systems through certain chemical substances. These substances are called hormones. These are produced by certain organs called endocrine organs. These organs directly discharge their secretions into the blood. Therefore, these organs are also called ductless glands. Pituitary, thyroid, pancreas and adrenals are some of the endocrine organs.

Reproductive System

The human body is able to reproduce a completely new living creature almost exactly like itself. The body has a separate group of organs, forming the reproductive system. The organs that constitute this system differ in males and females. In the male there are testes and certain other organs associated with them. In the female there are no testes, instead there are ovaries with certain other organs associated with them.

Though the human body appears to be made up of these system each system functions in close cooperation with others. This cooperation enables the human body to function as an integrated whole.

Summary

An animal cell is made up of a nucleus and cytoplasm. Animal cells differ from plant cells in being covered by a thin cell membrane instead of cell wall.

The nucleus which is the vital part of the cell has the chromosomes inside it. Chromosomes contain materials that control the hereditary characters.

Living cells carry out various vital activities like nutrition, respiration, excretion, reproduction and irritability.

Cells similar in appearance and function are organised into tissues. Epithelial tissue, connective tissue, muscular tissue and nervous tissue are examples of tissues. Different tissues constitute an organ. Different organs form an organ system.

There are nine major organ systems in our body. They are the skeletal, muscular, digestive, circulatory, respiratory, excretory, nervous, reproductive and endocrine systems. All these organ systems function in close cooperation with each other and thus the human body functions as an integrated whole.

Questions

1. Mention the names of different parts of an animal cell and their functions.
2. Name two cell structures found in plant cells that are not found in animal cells.
3. Name any three animal tissues. What are their functions ?
4. How is an organ related to tissues ?
5. List the different kinds of life activities, that take place in a cell.
6. Name the nine different organ systems in our body.
7. What are the different kinds of muscular tissues ? How are they different from each other.

Tasks

1. Examine under the microscope the epithelial cells from mouth cavity.
2. Examine the muscle fibres in a piece of boiled meat.
3. Examine microscopically stained preparations of different kinds of cells.
4. Study the different kinds of organ systems of our body with the help of a human torso model or chart.

Organs of Movement

Importance of the Skeletal and Muscular Systems

The various movements of the human body are made with the help of the skeleton and the muscles. When the striated muscles are contracted the position of the bones connected with one another changes mutually and movement becomes possible.

The skeleton and the muscles protect the important internal organs like the heart, the lungs, and the large-sized blood vessels which are situated inside the thorax.The brain is protected by the skull, and the spinal cord is inside a canal in the vertebral column.

The human body consists of about 65 per cent of water. In the muscles there is about 75 per cent of water. The soft organs containing much liquid need strong support. In the human body the skeleton serves as such a support. The bones also act as principal storehouses for the essential mineral substances of the body. The red blood cells and certain kinds of white blood cells are manufactured in the marrow of the bones.

Examine a thigh bone of sheep, cut lengthwise to understand its structure. The surface of a bone is covered by a thin membrane called **periosteum**. The greater part of a bone consists of the bony tissue.

Structure of Bone

The thigh bone has a ball-shaped head at its upper end which fits into the socket of the hip bone. The substance of the bone at the ends is loose and porous. This is called the **spongy bone**. In this region numerous irregular ridges and cavities occur. These cavities contain red marrow, which consists of blood vessels and cells that produce red blood cells and white cells (Fig. 3.1)

The bones are thicker at the ends. Between the ends the bone narrows into a slender shaft. There is cavity in the centre of the shaft filled with yellow marrow. The spongy structure and the cavities inside the long bones make the

skeleton considerably lighter in weight. If the whole skeleton were to consist compact bony tissue, it

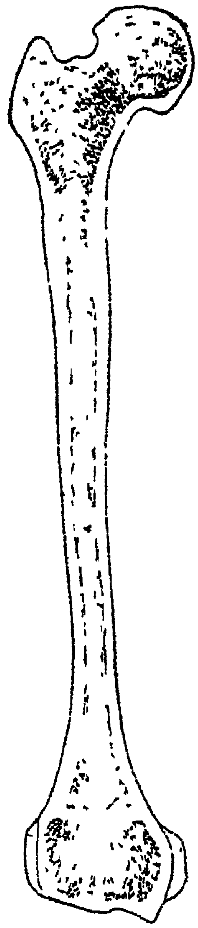


Fig. 3 1 Section of thigh bone to show its structure

would weigh twice or two and a half times its weight.

The bones are composed of organic substances and mineral salts like phosphate of lime. The organic substances give the bone its elasticity while the mineral matter gives toughness.

Take a piece of bone of any animal and put it on hot coal fire. All the organic substances present in it get burnt. You will find that the bone has become brittle and crumbles into powder even at a very slight pressure.

Take another piece of bone and. leave it immersed in a weak solution of hydrochloric acid for three days. Examine the bone after this. You will find that the bone looks the same but can be bent like rubber.

The composition of bones gradually changing in the course of years. The bones of children contain large quantities of organic substances but a small quantity of salts. Therefore, the bones of a child are more flexible and less brittle than those of an adult. That is the reason why children very seldom get their bones fractured. With the advance in age the bones get deposited with lime and the content of organic substance diminishes. The bones become harder and more brittle. It is due to this fact that old people are more liable to fracture their bones when they fall down.

There are about 200 bones in the body of a human being. These are connected with one another in various ways to form the skeleton.

For the sake of convenience, one can divide the skeleton into parts like the skull, the vertebral column the sternum and ribs, the girdles

and the limbs (Fig. 3.2).

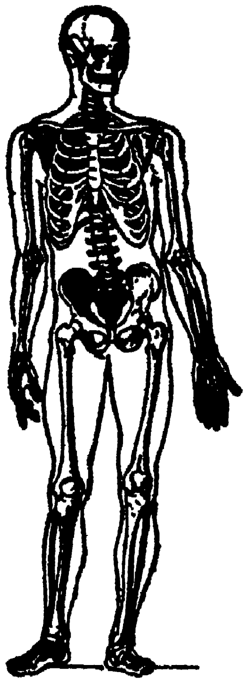


Fig. 3.2 Human skeleton

Skull

The skull has two main parts, the cranium or the brain case and the bones of the face. The cranium is formed of a number of bones. These bones are joined by sutures. The bones enclose a cavity in which the brain lies. The bones of the face include those of the upper and lower jaws and a number of other bones joined together.

The Vertebral Column

The vertebral column is composed of 33 vertebrae (Fig. 3.3). Each vertebra has a ring-like hole. As the vertebrae are placed one over another, these holes form a hollow cylinder which encloses the spinal cord.

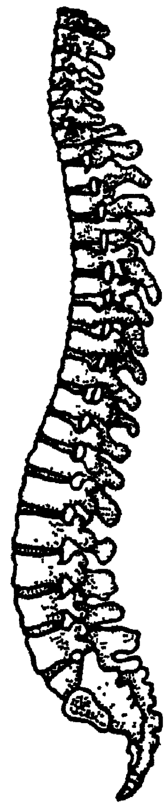


Fig. 3.3 Vertebral column

Five regions can be recognized in the vertebral column.

The first or uppermost region of the vertebral column is the neck region, which has seven vertebrae. These vertebrae are called **cervical vertebrae.**

The second region of the vertebral column is the thoracic region with twelve **thoracic vertebrae.**

The third region is the abdomi-

minal region. The vertebrae of this region are the largest and the heaviest. They are five in number and are termed the **lumbar vertebrae.**

The fourth region is the pelvic or the hip region. The five vertebrae known a **sacral vertebrae,** fuse to form the sacrum, a triangular bone that is wedged in the middle of the pelvic girdle.

The last region is the tail region or **coccygeal** region, which consists of four small vertebrae. They are fused to form the tail bone.

Chest Bones

The bones of the chest form a cone-shaped cage which encloses the heart and lungs. The chest bones together with the vertebrae of this region, protect the heart and lungs and the organs of the upper part of the abdominal cavity from shocks and injuries. In the middle and the front portion of the chest cavity lies the sternum or the breast bone. The sides of the chest cavity are formed of the twelve pairs of ribs (Fig. 3.4).

The first seven pairs of ribs are attached to the thoracic vertebrae at the back and to the flexible cartilages at the front. These cartilages in turn are fastened to the sternum. This attachment allows the chest to expand and contract during breathing movements.

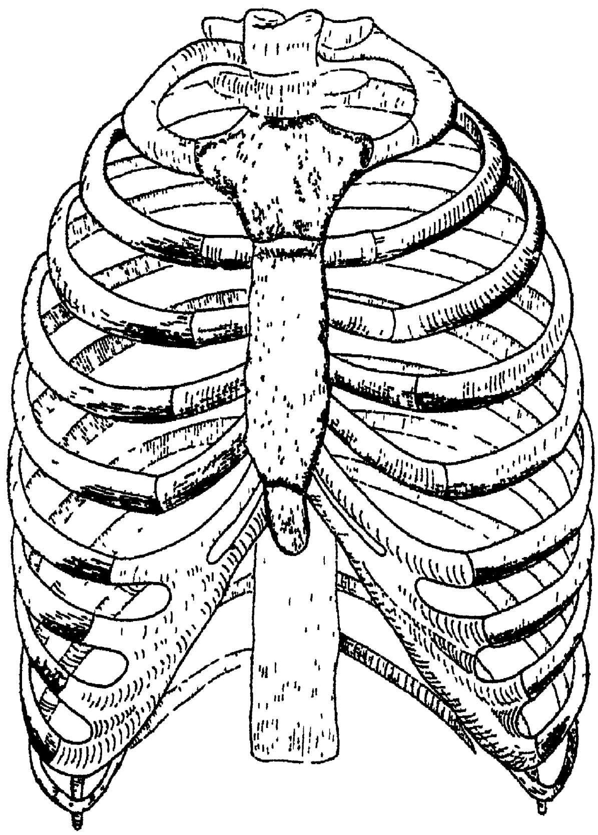


Fig. 3.4 Bones of the chest

Girdles

The bones of the limbs are attached to the girdles. The bone of the forelimb is attached to the **pectoral girdle** situated at the upper part of the body. The thigh bone is attached to the **pelvic girdle** situated at the lower part of the body.

The pectoral girdle is formed of two pairs of bones often referred to as shoulder bones.

The pelvic girdle is formed by the fusion of three pairs of bones (Fig. 3.6).

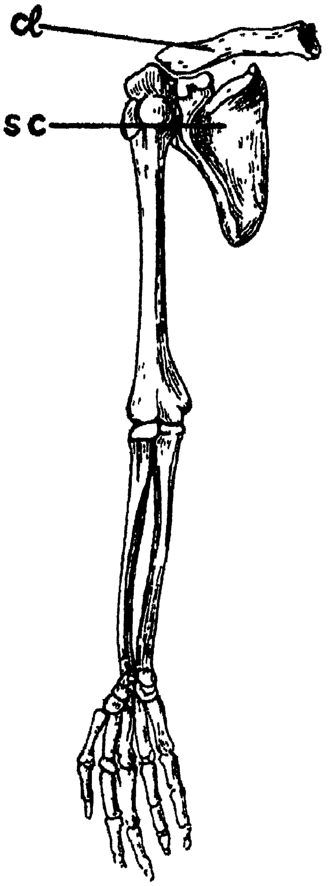


Fig. 3.5 Pectoral girdle of man with hand bones Cl. Clavicle ; Sc. Scapula

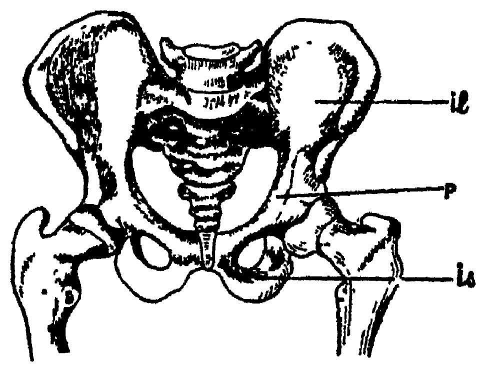


Fig. 3.6 Pelvic girdle of man : Il. Ilium ; P. Pubis ; Is : Ischium

Bones of Hand and Leg

The upper arm has a single bone, the **humerus.** In the forearm there are two bones the **radius** and the **ulna.** In the wrist there are small bones called **carpals.** The palm is composed of five long **metacarpals.** The fingers are supported by small finger bones called phalanges.(Fig. 3.7)

The skeletal structure of the **leg** is similar to that of the **arm** (Fig. 3.8). The **femur** or the thigh bone is the largest bone of the leg. Its upper end is ball-shaped fitting into the socket of the pelvic girdle. The knee joint is protected by a flat triangular bone, the knee cap or **patella**. The lower part of the leg is formed of two bones, the **tibia** and the **fibula**. The foot is made up of the bones of the ankle, the bones of the foot and the bones of the toes.

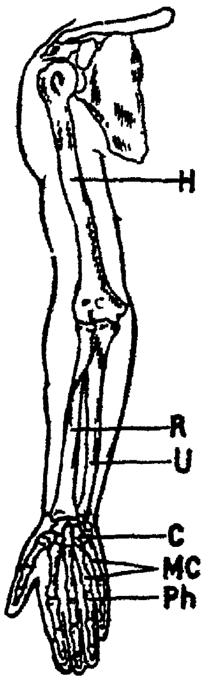


Fig. 3.7 Bones of the hand of man : H. Humerus, R. Radius, U. Ulna, C. Carpals, Mc . Metacarpals, Ph. Phalanges

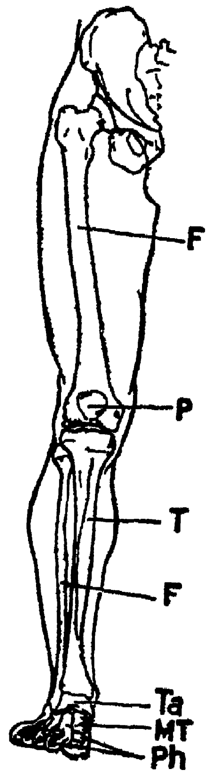


Fig. 3.8 Bones of the leg of man F. Femur ; P. Patella ; T. Tibia, F. Fibula ; Ta. Tarsus ; M.T. Metatarsus ; Ph. Phalanges

Human Skeleton : for Upright Posture and Work

You have seen and studied the skeletal system of different kinds of vertebrate animals. The skeletons of all the vertebrates including man possess certain similarities. But the skeleton of human body differs from those of other animals with regard to the erect posture.

All mammals except the human being, support themselves on all four limbs while walking. Even the apes are not exceptions, for in locomotion they not only use their hind legs, but also their forelegs to a greater or lesser extent.

The upright position has resulted in many changes in the human skeleton. The pelvic girdle is very broad and has the shape of a bowl. Such a shape and structure helps to support the weight of all visceral organs.

The joints in the human being are more movable than those in the animals and the thumb is diametrically opposed to all the other digits. These differences in structure are the result of differences in

functions. Animals use their forelimbs together with their hind limbs mainly for the purposes of locomotion, but the forelimbs of a human being are used for work.

Articulations of Bones : Joints

Bones are joined to one another in different ways to form the skeleton. Some bones are fused together and show no movement. Some other bones in our body are so joined that they can move.

The joints are given different names according to the nature of their articulation. They are as follows (Fig. 3.9) :

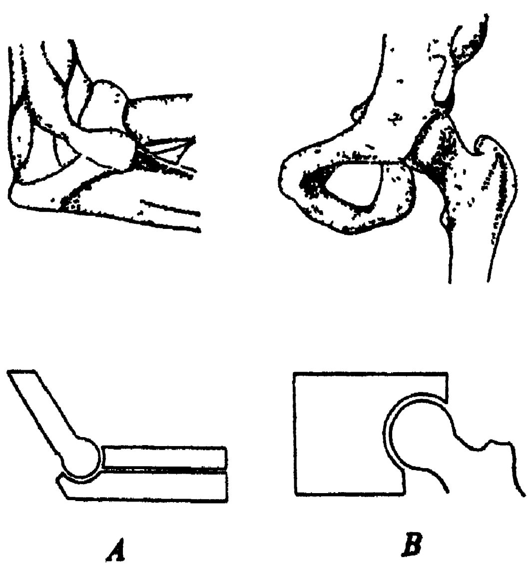


Fig. 3.9 Joints : A Hinge Joint, B. Ball and socket joint

1. **Ball and Socket joint.** In this joint a ball of one bone fits into the socket of another. Such a kind of joint makes movement possible in all directions, bending and stretching movement from side to side and rotation. The joints found in the shoulder and hip are of this kind.
2. **Hinge joint.** This joint is found in the elbow, knee and fingers (Fig. 3.9). The ends of bones fit into each other in such a way that movement is possible only in one direction. Such kinds of joints are known as hinge joints.
3. **Angular joints.** The joints at the wrist and ankle belong to this kind. The movement here is possible in two directions only.
4. **Pivot joints** In this kind of joint either the bones rotate on a ring or a ring rotates around a bone. In such cases either turning or rotating movement is possible. The skull rotating on the vertebral column and the junction of radius and the ulna are examples of this kind of joint.

Dislocation and Fracture

Dislocation

Any violent careless movement, a jump, fall or knock may result in an injury to the skeleton. The in-

jury may be a dislocation or a fracture of the bones. In the case of dislocation the bones at the joint are dislodged from their positions. For example, the ball of one bone may slip out of the socket of another bone into which it was fitting. When this happens, the ligaments are strained and often tear apart. Dislocations are often accompained by severe pain, especially when an attempt is made to move the injured joint.

Two basic rules must be observed when giving first aid to an injured person; firstly, never attempt to set a bone or joint yourself; secondly, put the injured parts of the body into the most comfortable position so that the person is in a state of rest and is not moved, and then get the help of a doctor immediately.

Fracture

A fracture is a break in the bone. The fracture may be simple or compound. Fractures very rarely occur in childhood and in early youth. In older persons fractures are common.

For first aid in case of fractures, the injured part of the body should be put into a position of complete rest. Whenever a fracture is suspected, either the docter should be called immediately or the injured should be taken to the hospital after first aid has been rendered. The injured person should be transporported with the greatest care.

Bandaging of the fractured part should be done with the help of a person who is well acquainted with the method. Sometimes splints are inserted in the bandage to prevent any movement of the injured part of the body. Splints may be made out of thin wooden boards or cardboards of sticks some soft padding should be placed between the body and the splint.

The splints are bandaged tightly, but strong pressure on the injured part of the body should be avoided (Fig. 3.10). Dirt, if any, should be prevented from getting into the wound if the skin is broken or torn.

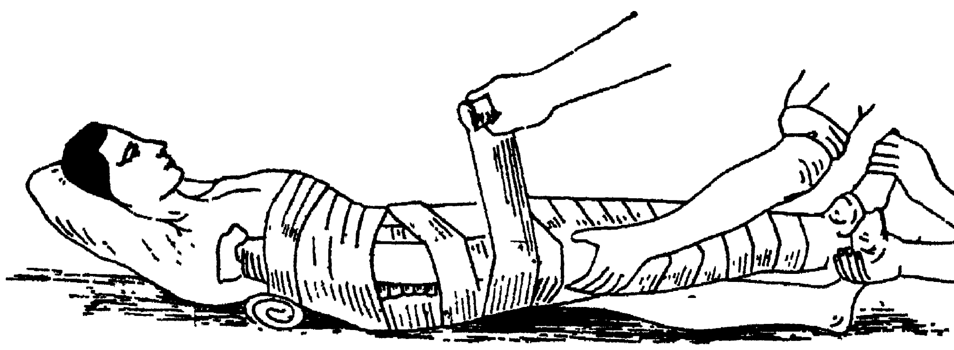


Fig. 3.10 Bandaging a fracture using splints

Muscles

Bones form the framework of our body; joints allow it to bend. Muscles do the bending when they pull the bones. The muscles required to move our framework constitute 40 to 50 per cent of our body weight.

All skeletal muscles are striated. The muscle usually terminates at each of its ends in very strong white cords called **tendons**. The muscles are attached to the bones by means of tendons.

Control of Muscles by Nerves

A muscle does not contract on its own accord. You can make a muscles contract in different ways. For example, if you dissect out a muscle from the thigh of frog and prick it with a pin or a pair of pincers it will contract. Touching the muscles with a hot wire, passing electricity through it, and placing a crystal of salt might also make it contract. The muscles found in the living body are subjected to the action of such artificial stimuli in exceptional cases. The normal, natural stimuli of our muscles are nerve impulses. If you carefully examine the muscle from an animal, you will find that the nerves are distributed inside it. The impulses that pass through these nerves cause the muscles to contract.

Contraction of the Muscles

Muscle fibres have the power of shortening. We call this contraction. You can see how the muscle at your elbow contracts. Fold up the lower arm of one of your hands. You will feel the bulge on the front of your upper arm. This is the contracted **biceps** muscles present in the front part of the upper arm. It has at its upper part two bundles. A pair of tendons anchor these two muscle bundles to the shoulder bone. The shoulder bone does not move when the muscle contracts. The other end of the biceps muscle is fastend to the radius of the arm just below the elbow. This bone is movable. When the biceps contract and the arm bends, the muscle gets shortened. This is all it can do. The biceps muscles has a counterpart on the lower side of the upper arm. These are attached to the shoulder bone above and to the ulna of the lower arm below. When these muscles, **triceps**, contract, they straighten the elbow and stretch the biceps into its first position.The two muscles, the biceps and the triceps work as a team. The one which bends a joint and its counterpart which straightens the joint.

Work done by Muscles

When an electric stimulus is

applied to the muscles, it contracts. Then it relaxes. The entire cycle requires about one tenth of a second. What will happen, if a muscle is stimulated continuously without allowing it to relax? It continues to remain in a state of contraction during the entire period. This continuous state of contraction is called **tetanus.** It is this sort of continuous contraction over a short period of time that is characteristic of muscular work. When we do work, like lifting weight, the muscles continue to remain in contraction. Once the weight is lifted, lengthening of the muscles occurs. When not in use, every muscle has a small number of fibres that remain in a state of contraction. This state of partial contraction of muscles is known as **muscle tone**. The tone indicates the readiness to do work. Fatigue produces a diminished tone. This is evident in the stooped shoulder and tired appearance of a fatigued individual. Relaxation and sleep brings back the increased muscle tone of the fatigued person.

You might have noticed that when you sit in one position and read for some time, you become tired. Do you know why ? It is because your muscles have become tired. If you get out and take a walk you feel that your fatigue disappears. Now an entirely new set of muscles is at work. The circulation is more rapid and the products of fatigue are being rapidly removed. After sometime you can again come back to your work with renewed drive.

Principal Groups of Muscles

There are more then 600

Fig. 3.11 Muscles of the human body

skeletal muscles. They may be divided into several main groups on the basis of their participation in the various movements of the body. They are the muscles of the head; muscles of the neck; muscles of the trunk; and the muscles of the limbs. (Fig. 3.11).

Importance of Physical Exercise and Games

Muscles that perform sufficient amount of work increase in size and become thicker and stronger. The more a muscle works, the greater is its need of oxygen and nutritive material, the muscular work not only strengthens the working muscles themselves, but intensifies the activity of the organs of respiration and circulation and in that way exercise the muscles of the thorax and heart. Besides, this good muscular work increases appetite, arouses a feeling of general vigour and as a result, the vital activity of the whole organism is increased. The contraction of the muscles also influences the bones. It helps in developing ridges on which the muscles can be firmly attached. Thus the activity of the muscles are also responsible for the proper development of the bones.

Generally, muscular work requires sustained effort on the part of the organism. But when the effort is combined with pleasure the organism can do the work without getting a feeling of doing hard work. Physical exercise games and sports combine pleasure with muscular work.

Playing of games and taking part in sports are important in strengthening the skeleto-muscular system in particular and the whole body in general.

Curvature of the Vertebral Column and Flat Foot.

There are hardly any curves in the vertebral column of a new born child. When a child is about 2-3 months old, he begins to lift up his head and hold it up The constant pull upon the muscles at the back which prevents the child from drooping his head forward, gives rise to a curve in the vertebral column at the neck.

Somewhat later when the child is able to sit up, a second curve, the thoracic curve, appears. When the child stands and walks the third curve, the lumbar curve, is developed.

The curves of the backbone change according to the way we sit and stand. If we crouch or walk with stooped back, then the backbone curves in an unhealthy way. At the back of the chest the curve

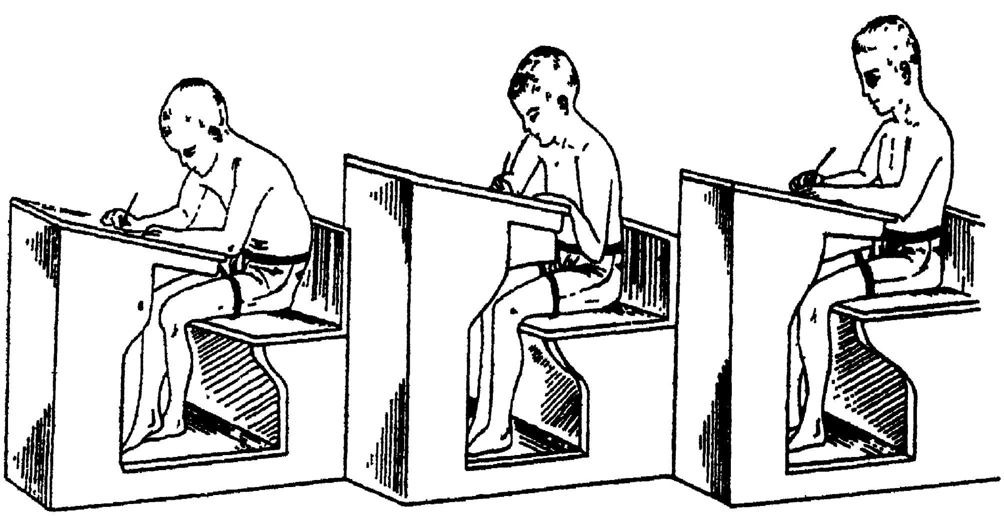
is made larger. In the lower part of the back the bones are squeezed together. If we carry a heavy load in one hand, the backbone curves to one side. There is danger that if we sit or walk in these ways as a matter of habit the backbone may become set and fixed in an incorrect position. This could give a mis-shapen body, clumpsy and awkward movements and disorders of the muscles and nerves.

After the age of 10 to 12, when rapid ossification of the skeleton takes place a curvature of the backbone that has developed cannot be corrected and this has a bad effect upon the general physical development, and on the working of the organs of respiration and the body as a whole. To avoid the curvature of the body, the muscles of the trunk and back should be trained. But very hard or long continued work is harmful since they prevent the proper supply of oxygen and nutrition to the working muscles.

The foot has curvatures. These arches strengthen the foot and give it a certain amount of springiness to the stride. Improper posture, excessive weight, fatigue, and improperly fitting shoes might lower the arches. The result is a flat-footed condition. This throws unnatural stresses and strain on the muscles involved in walking and may lead to increased fatigue and pain.

Correct Sitting and Working Posture

The correct and incorrect positions while sitting at a desk are



A B C

Fig. 3.12 Correct sitting and working posture. A and B. wrong postures C. correct posture

shown in Fig. 3.12. In a correct position one should sit straight and relaxed but without tension and leaning on the back of the bench, and not leaning in front on the table. The forearms should be at the same level. The feet should rest flat on the floor and the lower leg should be erect making a right angle to the knee joint.

Summary

The skeletal and the muscular systems make possible the various movements of our body. In addition, they protect certain vital internal organs from external harmful effects.

A bone is composed of bone cells arranged in a circle around a hollow canal. Among the bone cells is a large amount of material consisting of calcium carbonate and calcium phosphate.

The human skeleton is made up of the axial skeleton, the skull and the vertebral column ; and the appendicular skeleton consisting of the pectoral girdle, arm bones, the pelvic girdle and the leg bones.

The human skeleton shows adaptation for upright posture and work.

The movable articulations of the bones of our body result in joints. The joints are of several types and provide for different kinds of body movements.

Contractions of muscles cause body movements. The striated muscles or voluntary muscles attached to the skeleton. They can be controlled at will. Muscles flex and extend the limbs by means of tendons which are attached to the bones. Muscle contraction begins on the receipt of a nerve impulse.

There are more than 600 skeletal muscles in our body that are grouped into the muscles of the head, neck, trunk, and limbs. Physical exercises and sport help our body in building strong muscles and bones.

Maintaining erect posture in relaxed way during sitting, working and standing will help the body in preventing the abnormal curves of our body. These abnormal curves, if once formed will hinder the proper respiration and efficiency of the work of our body.

Questions

1. What are the four main functions of the skeletal system of our body ?
2. In what ways are the bone structures of a leg and foot similar to that of an arm and hand ? How are they different ?
3. Name six kinds of joints and give one example of each ?
4. (a) Explain how a fracture is different from a dislocation.
   (b) What is the first aid you will render in case of a fracture ?
5. (a) What are the causes of curvature of the vertebral column and development of flat foot ?
   (b) How can these be prevented ?

Tasks

1. Examine the various parts of a human skeleton.
2. Study the movements of the different joints of your body.
3. Study with the help of chart or model the different groups of skeletal muscles of your body.
4. Demonstrate the first aid in case of dislocation and fracture of bone.
5. Demonstrate the correct sitting, working and standing postures.

CHAPTER IV

Food and Digestion

Suppose you do not take food for several hours. How would you feel ? You might feel very weak and tired. You would also find it difficult to work. Energy is needed for doing any kind of work. The food you eat provides you that energy. Even when you are sleeping or sitting quietly, organs like the heart and the lungs, go on working. Energy is needed not only for doing physical work, but also for the working of many organs inside your body.

You might have heard about some people going on hunger strike. They do not take food for a number of days. They lose weight quickly and beeome thin and extremely weak. If they continue to remain for long without food, they may finally die. Food is the source of energy for our body.

COMPOSITION

Foods are made up of different kinds of essential substances called nutrients. They are carbohydrates proteins, fats, mineral salts and vitamins.

Carbohydrates

Certain kinds of substances are collectively known as carbohydrates. Starch, sugar and glucose are some examples of carbohydrates. Wheat, rice, corn and millets are mainly composed of starch. Carbohydrates provide the body with energy to do work. The diet of most Indians is mainly composed of carbohydrates.

Proteins

Pulses, meat, fish, egg, cheese and curd are rich in protein. Proteins help in the growth of our body. Since the childrens' body grow rapidly, they require more of proteins in their food, than the adults. The food, which many

ordinary Indian children take, does not contain enough proteins required for their bodies.

Fats

Fats are present in oils, ghee, butter, egg, milk and nuts. Fats also provide energy to our body. Fats provide more energy than carbohydrates. Our body needs more of fat during winter months to keep our bodies warm.

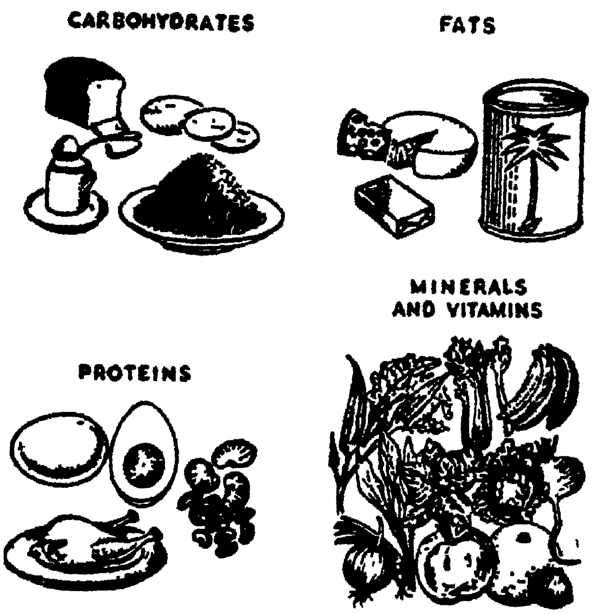


Fig. 4 1 Food stuffs containing protein, fat mineral salts, Carbohydrates and vitamins.

Mineral Substances

Calcium, phosphorus and iron compounds are essential for the proper growth of our body. Sufficient amounts of calcium and phosphorus compounds are necessary for the formation of healthy bones and strong teeth. Iron compounds are required for the formation of red blood cells. Milk, cheese, meat eggs and green vegetables contain, these mineral substances.

Vitamins

You might have heard about vitamin tablets sold in drug shops. The doctors ask patients to take certain vitamin tablets when they suffer from certain diseases. Vitamins are present in small quantities in various kinds of food items we eat. When food is overcooked many of the vitamins are lost. Vitamins are essential for the proper growth of our body. Lack of vitamins in our food leads to certain deficiency diseases.

The vitamins which are of various kinds are often referred to by certain alphabets like A, B, C, D and E. You will learn more about the vitamins and their importance in Chapter VII.

ROLE OF DIGESTION

The substances found in the food are ultimately converted into substances of the cells. This is not a simple process. The food under-

goes many changes before this final conversion.

The food we eat gets into the food canal. The food materials must be absorbed through the wall of the food canal to reach the different parts of the body. Many substances cannot pass as such through the wall of the food canal. They should first be converted into simpler forms. The conversion of food into simpler forms is done in two ways. One is the breaking down of food into small pieces. The other is the splitting up of the complex particles of proteins, fats and carbohydrates by digestive juices. The conversion of food materials into simpler substances so as to pass through the walls of the food canal is known as digestion.

Enzymes

The splitting up of the complex food substances, into simpler ones is done by certain substances secreted by the food canal or certain organs associated with it. These substances are called **enzymes**. These enzymes act as biological catalysts. These catalysts accelerate chemical reactions.

The enzymes are of different kinds. Each enzyme acts on a particular nutritive material and helps in splitting it into simpler substances. For example, a particular kind of enzyme acting on starch cannot act on any other nutritive material. Thus the action of an enzyme is highly specific. In the course of action of an enzyme on a nutritive material, the enzyme itself does not undergo any change. It only helps to speed up the splitting of the complex nutritive materials into simple substances. All carbohydrates are finally split into glucose, all proteins into amino acids. These are simple substances and they are absorbed by the network of blood vessels in the wall of the food canal.

THE ALIMENTARY CANAL

We take food daily. Some people do not know how this food is changed in the alimentary canal (Fig. 4.2). We cannot see the changes that happen to the food there. But we know what happens to the food in the mouth.

Mouth

The food is chewed in the mouth. Chunks of food are rolled around and placed between the teeth by the action of the tongue and cheeks. Chewing breaks up the food into smaller pieces.

Teeth

A human being has 32 teeth; 16 each in the upper and lower jaws. All our teeth are not of the same kind. Four kinds of teeth are recognized (Fig. 4.3). The four front teeth of each jaw are called as **incisors.** Following them on either side, there are one **canine,** two **premolars** and three **molars.**

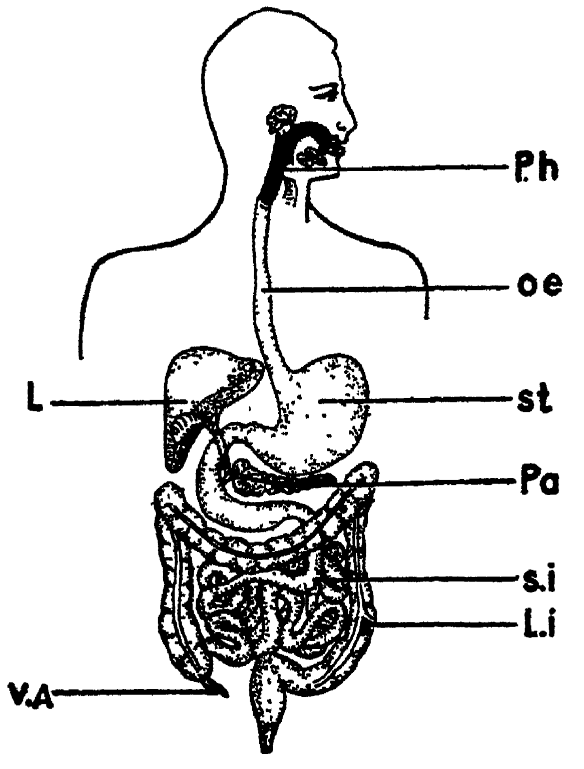


Fig. 4.2 Alimentary canal of man ; Ph. Pharynx; Oe. Oesophagus; St. Stomach; Pa. Pancreas; L. liver; S. i. Small intestine, L. i. Large intestine; V.A. Vermiform appendix

The incisors help in biting the food. The canines are useful in tearing and breaking large pieces of food. The pre-molars and molars help in chewing and grinding our food.

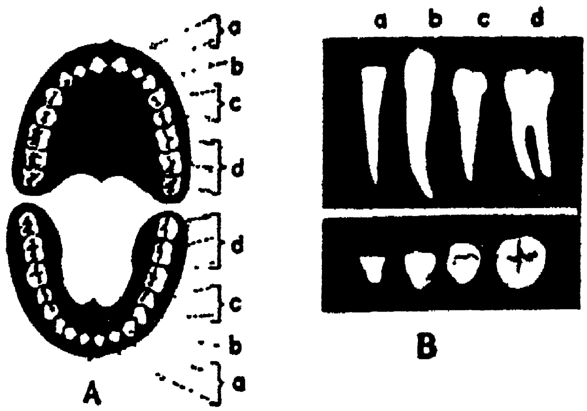


Fig. 4.3 A and B. Different kinds of teeth a incisor; b. canine c. premolar; d. molar

Count and see how many teeth a young child 3-5 years old has. You will not find all the 32 teeth that one finds in an adult. A child has only twenty teeth, ten in each jaw. They are four incisors, two canines and four pre-molars in each jaw. These teeth are known as **milk teeth.** They are not permanent teeth. You might recall that when you were 6-8 years old, some of your teeth were falling off and new teeth growing in their places. The permanent molar teeth also begin to grow. The last molars, are called 'wisdom teeth'. They come out only when a person is twenty years old or more.

Each teeth is made up of a solid tissue (Fig. 4.4) called **dentine.** This is a kind of bony tissue. The teeth are embedded in special sockets of the upper and lower jaws. The part

of the tooth embedded in the socket is the root and the part that projects out is the crown. Inside each tooth there is a cavity filled with tissue containing blood vessels and nerves. The blood vessels enter the tooth through fine canals at its root. The surface of the crown is covered with a layer of very strong tooth enamel (Fig. 4.4).

The enamel protects the underlying parts of the teeth. Any injury to the enamel leads to gradual decay

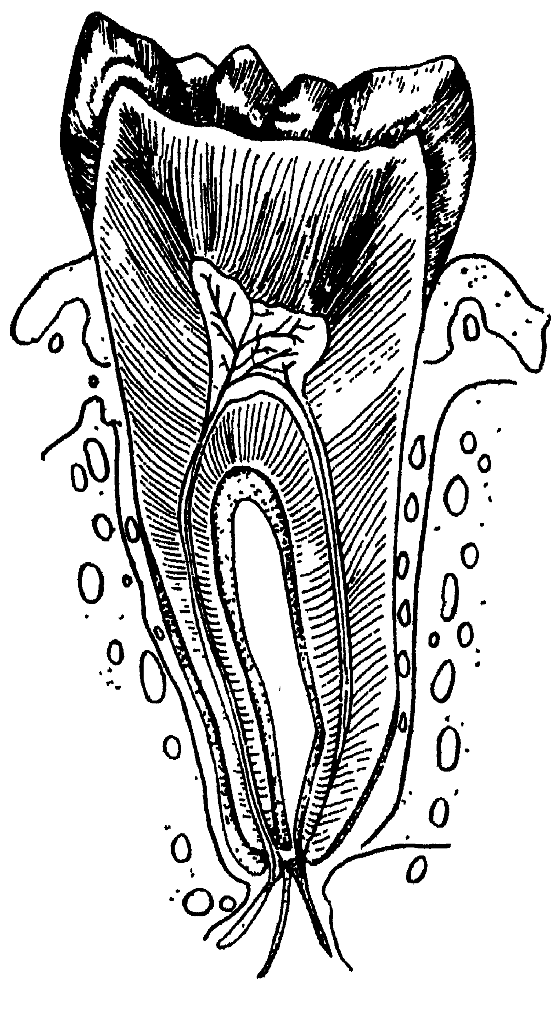


Fig. 4.4 Vertical section of a human tooth

of the tooth. Decay in one tooth will always spread to the neighbouring teeth. Particles of food lodged between the teeth get decayed and start the decay of the teeth. In order to avoid decay of the teeth it is necessary to brush your teeth before going to bed and after getting up from bed. The mouth should be cleaned well with water after each meal.

The enamel in children is very thin. The milk teeth are very fragile. Therefore, the teeth of children are more liable to decay than those of the adults. Very hot and cold food taken one following the other, sometimes, causes the enamel to crack making it easy to decay. Rubbing the teeth with sand or brick powder removes the enamel from the teeth. Decaying teeth bring out fowl odour in the mouth and certain other diseases like frequent stomach pains. Each set of our permanant teeth serves us for our life-time and they need great care for maintenance.

As the food is chewed, it gets mixed up with saliva, which softens and moistens the food. What is saliva ? It is a juice secreted by certain glands in our mouth. There are three pairs of them and these are called **salivary glands** (Fig. 4.5). The saliva secreted by these glands are poured into the mouth by ducts. You might have noticed that when

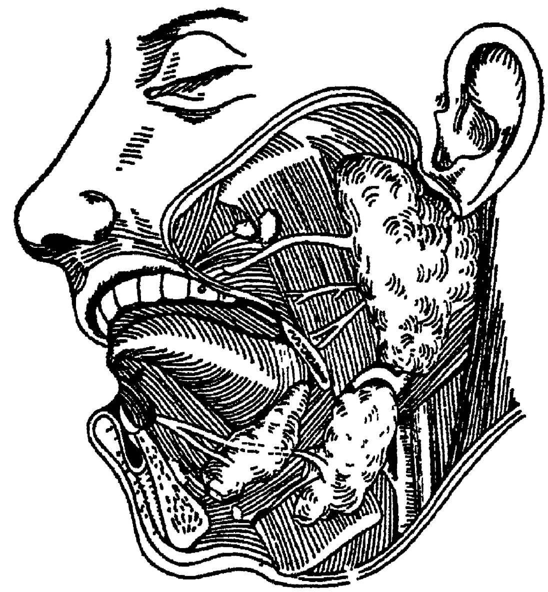


Fig. 4.5 Salivary glands of man

you see or smell or think of good food your mouth begins to water. The saliva contains the enzyme known as **ptyalin.** Ptyalin changes starch into a form of sugar known as maltose. Maltose is soluble in water and is somewhat sweet. If you chew bread, or potato or rice long enough it dissolves slowly in your mouth and tastes sweet. The food moistened by saliva and well masticated by teeth is propelled into the pharynx by the movement of the tongue. Just below the pharynx there is a common passage for the food and the air we breathe. From the common passage the food enters the food passage and the air enters the air passage. The entrances to these two passages are automatically controlled without one being aware of it. When the food reaches the food passage, the air passage to the lungs is closed. The food then passes into the oesophagus. Sometimes, when we hurriedly take our food, some food particles might enter the air passage. These particles will be forced out quickly by violent coughing.

Oesophagus

The oesophagus is a long muscular tube. The food passes through the oesophagus as small balls. These balls of food are pushed along the oesophagus without any voluntary effort by us by waves of muscular contraction.

Stomach

The food from the oesophagus reaches the stomach, which is the widest part of the alimentary canal. The stomach squeezes, twists and churns its contents. This action of the stomach brings the food to a semi-liquid state.

The inner lining of the stomach has millions of minute glands. These glands secrete the **gastric juice.** The gastric juice contains 0·3-0·5 per cent of hydrochloric acid, and the enzymes **pepsin** and **lipase.** The hydrochloric acid dissolves the mineral substances in the food. It also destroys many bacteria that get into the stomach along

with the food. The enzyme pepsin can act only in the acid medium.

Even after the food has entered the stomach, the ptyalin of the saliva continues to act on the starch. But ptyalin ceases to act when the food contents become acidic by being mixed with the gastric juice.

Then the enzyme pepsin acts on the protein of the food breaking its molecules into simpler intermediate forms. These products are soluble in water. But these must be further split up into the simple amino acids to complete the digestion of protein. This is carried out in the small intestine into which the food passes next.

Gastric lipase digests fats, splitting them into fatty acids and glycerol. It acts on emulsified fats such as the fat contained in milk, which is suspended in the form of minute droplets.

Small Intestine

The small intestine (Fig. 4.2) is the most vital part of all digestive organs. The complete digestion of fats, proteins and carbohydrates is done in the small intestine. The digested food is absorbed by the walls of the small intestine.

The small intestine is a coiled tube about 2·5 cm in diameter and 7 metres in length. It is the longest part of the alimentary canal. The pancreas and the gall bladder open into the small intestine at its upper part through their ducts.

Pancreas

The pancreas is a cream coloured gland situated behind the stomach (Fig. 4.2). It secretes **pancreatic** juice. There are three enzymes in this juice which act on all the three classes of food.

Liver

The liver is a dark brown gland situated in the upper part of the right side of the abdominal cavity. This is the largest gland in the body; it weighs about one kilogram in an adult. The liver is richly supplied with blood. A vein which collects the blood from the stomach, the intestine and the pancreas, opens into the liver.

One of the functions of liver is to secrete bile, a brownish green fluid. It does not contain any digestive enzymes. But it is essential for the digestion of fats. You might have observed that fats do not mix well with water. But bile alters them into an emulsion. The emulsified fat is acted upon by enzymes in the small intestine.

A large number of minute glands called intestinal glands are embed-

ded in the inner lining of the small intestine. This juice contains four different kinds of enzymes. One of them converts protein into amino acids and the other three convert carbohydrates into glucose. The digestion of food begun in other parts is completed in the small intestine. Glucose, fatty acids, and amino acids are the end products of digestion. They can be now easily absorbed.

Absorption

The small intestine is well suited for the absorption of soluble, digested foods. The inner walls of the small intestine are lined with millions of tiny fingerlike projections called **villi** (Fig. 4.6) each villus contains a network of capillaries twisted around a central closed canal. Molecules of fatty acids pass into the villi and enter the central canal. Amino acids and glucose enter the capillaries and are then transported by the blood. Water and indigestible matter that has not been absorbed by the small intestine enter the large intestine.

When the abdominal cavity of freshly chloroformed animal is exposed, the slow worm-like movements of the small intestine may be observed. These movements are produced by the slow, periodic contractions and relaxations of the muscles in the walls of the intestine. At a time only a small part of the intestine contracts and relaxes. This takes place in a succession along the length. Thus the movement goes along the whole intestine resembling

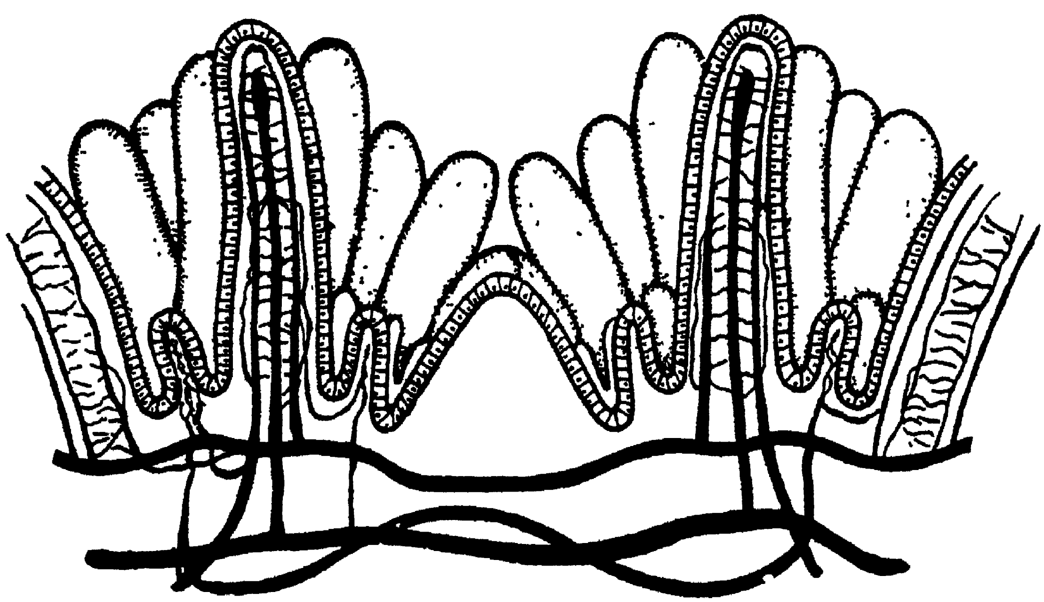


Fig 4.6 Villi (whole and section)

waves.

Such wave-like movements of the intestine wall, following one another in quick succession is known as **peristalsis**. Due to peristalsis, the contents of the intestine are kept churning, mixing and moving slowly through the intestine.

Large Intestine

The large intestine is also called **colon**. Below the junction of the small intestine with the large intestine, there is blind sac-like region called the **caecum**. In herbivorous animals like horses and rabbits the caecum is very large in size. In the caecum, the cellulose of plant cells taken as food is split up with the help of certain bacteria. The caecum of human being is small compared to the herbivorous animals.

A small worm-like outgrowth arising from the caecum is the **vermiform appendix** (Fig. 4.5). This organ has no use for the human body. It sometimes proves to be troublesome to a person. Food collects and decays there, or intestinal worms settle there and may cause inflammation of the appendix. This condition is known as **appendicitis**. In such cases an operation is performed and the appendix is removed. The person is not handicapped in any way by the removal of the appendix.

The undigested materials and water are passed along the large intestine by peristalsis. The large intestine has no digestive function. By the time the watery contents of undigested food reaches the lower part of the large intestine, much of the water is absorbed by the walls of the large intestine.

Some people suffer from diarrhoea occasionally. The dircharge of the contents of the large intestine in a watery condition is known as **diarrhoea**. During diarrhoea the large intestine becomes overactive and forces its contents out very rapidly before the water is absorbed in normal quantities.

The last segment of the large intestine through which the waste material is eliminated to the exterior is called the **rectum**. It opens to the outside through the anus. The faecal matter is thrown out through the anus.

Constipation and its Causes

When the undigested part of the food remains longer in the large intestine, the faecal matter becomes hard due to loss of water. In this condition one feels great difficulty in passing out the faecal matter. The movement of bowels becomes irregular. Such a condition is called **constipation**. Because of greater activity of bacteria, gas is formed

and collected in the large intestine in this constipated stage. One feels dizzy and sluggish due to constipation. Headache is also felt. Old people often complain of constipation. In them the muscles of the large intestine become weak resulting in slow peristalsis and this leads to constipation.

Constipation in young people might be due to lack of 'bulky' food in the diet. Bulky materials stimulate the muscles of the large intestine and cause peristalsis. Without the bulky material the contents of the large intestine move slowly resulting in dry faecal matter.

Sometimes drinking insufficient amount of water might result in constipation. Constipation might be common during hot weather because of the excessive absorption of water from the large intestine which is lost as perspiration. Irregular habits in bowel movement can also result in constipation.

Constipation can be prevented by observing the following. simple rules :

(a) including fruits and similar 'bulky' food matrials in the diet.
(b) drinking plenty of water.
(c) practising regular bowel movements.

Conditions for Normal Digestion

Normal digestion of food depends upon the glands secreting the digestive juices. The work of the glands affect one's appetite to a great extent. The secretory activity of the digestive glands depends on many things. The taste of the food, the ingredients that make up the food, the methods of preparing the food and attractive way in which food served, influence the secretion of digestive juices. A dirty table, eating while standing, gulping down food in a hurry, reading while eating can reduce the secretion of juices and thus reduce the appetite. Attractive display of the dishes and the fine aroma of food often increase the desire for food.

A person's mood is also of great importance in the work of the food canal. Worry, grief, anger and excitement may bring to a complete stand-still the secretion of juices already begun and thus result in loss of appetite.

Summary

Food is required for providing energy for tissue building and for the overall promotion of good health. Foods are made up of five classes of essential substances called nutrients. These are

carbohydrates, fats, proteins, mineral salts and vitamins.

Carbohydrates and fats yield energy. Fats yield more than twice the amount of energy as carbohydrates. Proteins are tissue builders that are essential for growth.

Mineral salts present in minute quantities in all foods influence our body functions. Salts of calcium and phosphorus are essential for bone building. Iron is required for the formation of haemoglobin of the red blood corpuscles.

Vitamins regulate many body functions. Their absence from the diet results in deficiency diseases.

Digestion is mainly a chemical process. Enzymes in the mouth, stomach and small intestine split large food molecules into smaller ones. These simple products are then absorbed into the blood and distributed to the cells of the body.

Human beings have two sets of teeth, milk teeth and permanent teeth. The milk teeth are lost by the age of twelve. They are replaced by 32 permanent teeth. Tooth decay may be due to bacteria, poor diet or lack of dental care.

Digestion of starch begins in the mouth. Protein digestion begins in the stomach and fat digestion in the small intestine. Bile from the liver emulsifies fats before they are acted upon by lipase, a fat-splitting enzyme,found in the pancreas and intestinal glands. Further digestion of starches, sugars and proteins occurs in the small intestine.

The movement of food in the digestive tract is brought about by the peristaltic contractions of the muscle layers. Digested food are brought into close contact with the villi of the small intestine. Amino acids and glucose are absorbed into the capillaries of the villi, while fatty acids are absorbed into the lacteals. The large intestine mainly absorbs the water.

Constipation is due to prolonged retention of undigested food materials in the large intestine. It results in headache, dizziness and gas formation. It can be prevented by practising regular bowel movements, taking 'bulk' food and by drinking plenty of water.

Normal digestion of food depends upon the taste and flavour

of food, the attractive way it is served and the happy mood of the person who eats the food.

Questions

1. List five foods rich in carbohydrates, fats and proteins.
2. What are the roles of calcium and phosphorus in body growth ? Name several good source of these elements for our body.
3. What is the role of digestive enzymes ?
4. Describe four kinds of permanent teeth.
5. Why is it impossible to talk and swallow at the same time ?
6. What happens to the different kinds of food materials in the small intestine ?
7. (a) What is meant by Constipation ?
   (b) What are its causes ?
   (c) How can it be prevented ?
8. What are the various conditions necessary for the normal digestion of food ?

Tasks

1. Find out the action of saliva on starch.
2. Test the action of gastric juice taken from any small carnivorous animal on protein (boiled white of egg).
3. Study the villi in the small intestine of a rat.
4. Study the organs of digestion with the help of a chart or a model.

CHAPTER V

Blood and Blood Circulation

You have learnt that our body is made up of millions of cells organized into tissues and organ systems. The cells grow, divide and increase in number and release energy. Nutritive materials are required for all these processes. The nutritive materials are obtained from the food we eat. The digested food has to be taken to different parts of the body. This is done by the blood during its circulation in the various parts of our body.

What is blood? How is it carried to different parts of the body? What organs help in the circulation of blood? What are the other functions of the blood? In this chapter you are going to find out the answers to these questions.

Blood : Composition

Everyone is familiar with blood. It is a red liquid that comes out of our body when a cut is made. Examine under the microscope a thin smear of blood on a slide. You will be surprised to find that it is not mere liquid. There are a large number of particles in it. Each of these particles you find is a cell. These cells are suspended in a liquid called plasma. The cells are of three main types (Fig. 5.1 a, b, c).

The corpuscles are tiny disc-shaped cells with both sides concave. They are the most numerous in the blood. In one millilitre of human blood there are about 4.5 to 5 million red corpucles. They give the

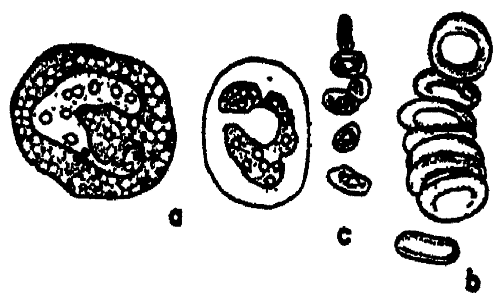


Fig. 5.1 Blood corpuscles : a. White blood corpuscles; b. Red blood corpuscles; c. Blood platelets

blood its red colour. The red corpuscles of mammals (including human beings) have no nuclei in them.

What is the colour of red corpuscles due to? The red colour is due to the presence in them of complex substance called **haemoglobin.** This is a protein compound having a red pigment containing iron. Haemoglobin can readily unite with oxygen and can also give it up easily. When the blood flows through lungs, the oxygen of the air contained inside the lungs is taken up by the haemoglobin of red corpuscles. As the corpuscles move in the blood stream, oxygen is carried to the various tissues of our body. The haemoglobin gives out its oxygen to the tissues where it is necessary.

Illness, poor nutrition or loss of blood may often result in a serious reduction in the number of the red blood corpuscles. Sometimes the number of corpuscles may remain normal, but the haemoglobin content in each corpuscle is reduced. In either case, the ability of the blood to absorb oxygen is diminished. This causes general weakness and sluggishness, loss of appetite and constant fatigue. Such a condition of the body is known as anaemia.

Besides red corpuscles the blood contains white corpuscles. They are larger in size but fewer in number. They have nuclei and constantly change their shape like an *Amoeba.* They can move along the walls of the blood vessels and even in a direction opposite to the blood current. The white corpuscles can escape through the thin walls of the minute blood vessels. Those that have come out of the blood vessels wander among the tissues of the body.

The white corpuscles are colourless. They usually collect in large number in places where bacteria or other foreign bodies occur. They attack the bacterial cells and destroy them. Like an *Amoeba,* a white corpuscle engulfs bacterial cell and digests it inside its body. The main function of white corpuscle is to attack foreign organisms and eliminate them from the blood.

When the body is infected by harmful bacteria, the number of white cells in the blood is increased. Ordinarily the number varies from 5,000 to 8,000 per ml^3. When there is an infection the number may increase upto 30,000 per ml^3.

There is another variety of particles in the blood. These are the platelets. They are less numerous than the red corpuscles. There are from 300 to 500 thousand of them in a ml^3 of blood. Platelets are essential for the clotting of blood.

Plasma

The liquid part of the blood is

called **plasma.** It is yellowish in colour. It makes up about 55 per cent of the total blood. About 92 per cent of plasma is water. The remaining 8 per cent is made up of proteins dissolved nutrients and mineral salts. The plasma carries food to the tissues and transports waste products from the cell. It also removes any excess of heat produced in a cell.

Where are the Corpuscles Formed ?

The corpuscles in the blood are not permanent. After sometime both the red and white corpuscles die and disintegrate. New red corpuscles are formed in the marrow of bones. Some of the white corpuscles are formed in the bone, but other kinds are produced in the spleen and the lymph nodes.

The Functions of Blood

The blood transports all substances that are required by the cells and also those that are discarded by them. You have already learnt that the gases concerned in respiration are carried by the blood. Oxygen is carried from the lungs to the cells by the haemoglobin of the red blood corpuscles. The waste product carbon dioxide is collected from the tissues and carried to the lungs by the plasma.

Food materials rendered soluble by digestion are absorbed into the plasma and are transported to the various parts of the body. In a similar way the waste materials from the cells are carried by the plasma to those organs from where they can be eliminated to the outside. The blood also transports the hormones that are produced by certain glands.

Maintenance of body temperature : When a tissue like the muscles is very active, heat is produced. Any accumulation of heat is harmful to the tissues. The excess of heat is taken away by the blood and spread over the surface of the body and lungs. From here the heat is lost to the outer atmosphere. Water balance should be present in the tissues for their normal functioning. Sometimes the water contents of certain regions of the body are decreased due to increased chemical activity. The loss in water of these regions is made good by the blood.

Protection against diseases : The white corpuscles of the blood fight the invading microbes. The pus that is formed in the wounds is composed of the dead white corpuscles and damaged remains of tissues.

Clotting of Blood

Draw some blood in a beaker from a freshly killed sheep. Observe as to what happens to the blood in

course of time. After it is drawn into the beaker it begins to thicken rapidly. In a few minutes all the blood turns into a jelly like clot and does not pour out of the beaker. The blood is said to have clotted or coagulated. If you continue to watch the clot for several hours you will see that it gradually shrinks and floats up in a yellowish liquid (Fig. 5.2).

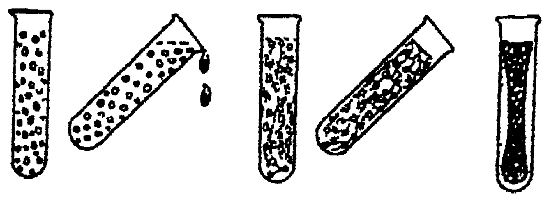


Fig. 5.2 Clotting of Blood

If the process of blood clotting is observed under the microscope, it can be noticed that very fine filaments appear one by one in the plasma. These interlace with corpuscles gradually. The corpuscles entangled in the fibres is the blood clot.

You might wonder as to why the blood does not clot so long as it remains inside blood vessels. Blood clots only when it comes out of the blood vessels. The clotting of blood is due to the presence of certain chemical substances that are produced only when the blood comes out of injured blood vessels.

The substance that causes clotting of blood is **fibrin.** This is an insoluble protein. What you see in the figure as thread-like structures is fibrin (Fig. 5.3). Fibrin can be easily obtained by beating up with thin little sticks some fresh blood, drawn from a blood vessel. It will collect on the stick as a mass of thin fibres. The fibrin is formed from a protein substance dissolved in the plasma of blood. This is known as **fibrinogen**. Fibrinogen reacts with another substance called **thrombin** and finally becomes **fibrin.** Thrombin forms as a result of a chemical reaction of some other substance in the presence of calcium.

When any one of the substance needed for clotting is not avilable, clotting does not take place. You might have seen doctors taking the blood for examination. As soon as he obtains the blood he adds some solution of sodium oxalate. This substance prevents the coagulation of blood. How does sodium oxalate prevent the coagulation of blood ? Sodium oxalate reacts with the calcium of the blood and makes it unavailable to take part in coagulation. Calcium, as already indicated is one of the essential substances required for the blood to clot.

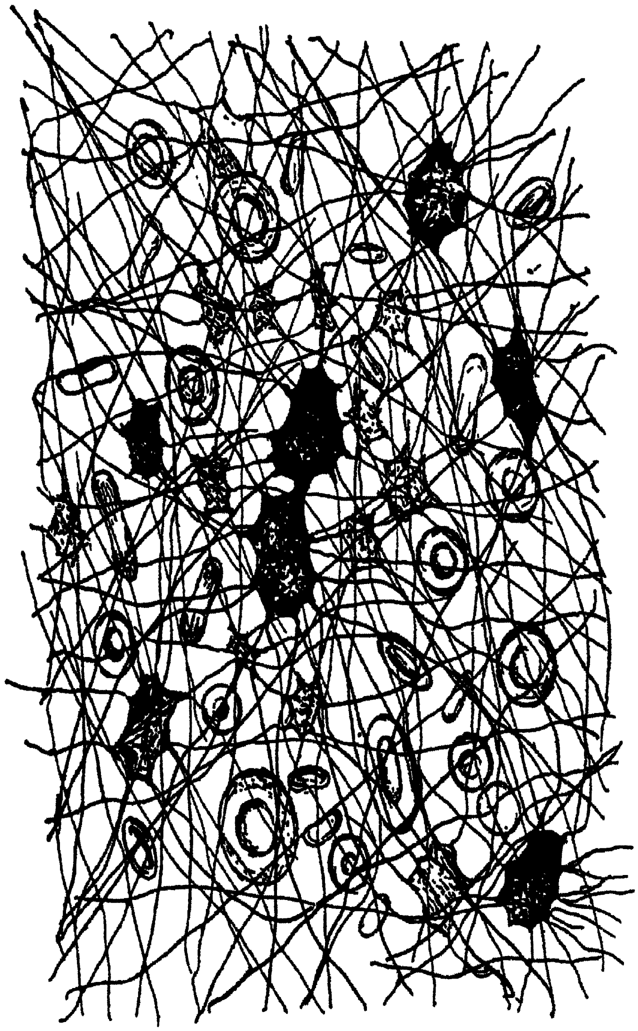


Fig. 5.3 Fibrin as seen under microscope

Thrombosis

The blood inside the blood vessels does not normally coagulate. But in cases persons suffering from rheumatism and some other diseases, inner membrane of the heart or of a blood vessel is sometimes affected. The blood begins to coagulate at a place where the injury has occurred and little clots of blood are formed. A tiny particle of the blood clot may be separated out, it may be carried into the blood stream and might clog one of the blood vessels. This is known as the **thrombosis.** Thrombosis of the vessels of the brain or heart may cause serious illness and even prove fatal.

BLOOD GROUPS AND BLOOD TRANSFUSION

Sometimes in an accident or illness a person loses a great deal of blood. Unless this loss is replaced he is likely to die. A doctor can save his life by introducing into his veins blood from healthy person. This process is called **blood transfusion.** The person who gives the blood is called the **donor** and the patient who receives is called the **recipient.** But blood transfusion is not so simple as stated above at times. Its is difficult to find a suitable person who can donate blood of the right type and at the right moment when it is needed.

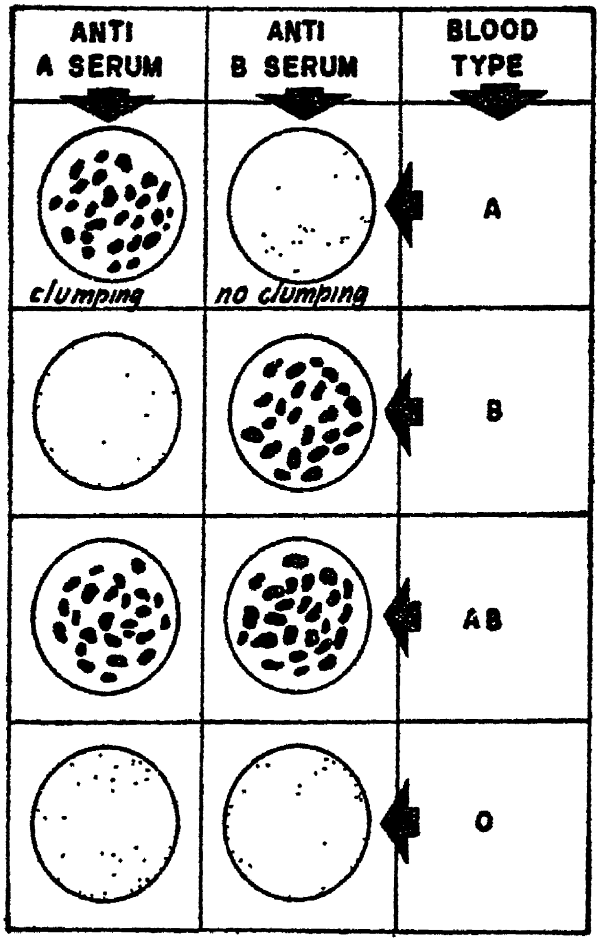


Fig. 5.4 Blood groups

History of Blood Transfusion

Blood transfusion has been attempted for centuries in the past. Most of these attempts ended in failures. The patient died. These failures puzzled the doctors of those days. In 1900, Landsteiner, a Viennese doctor solved this puzzle. By experimenting on blood samples, he proved that there are several groups of blood.

Blood Groups

Landsteiner classified human blood into four groups (Fig. 5.4). He called them A,B,AB and O. These names were given to them because of some substances that the blood possessed. Blood of group A has **antigen A** on the surface of the red corpuscles. Similarly blood of group B has **antigen** B and blood of group AB has **both antigen** A and **B**, and the blood of group O has neither of the antigens. The serums of the blood also have other substances known as **antibodies.** The blood of group A has antibody B and the blood of group B has antibody A and the blood

of group AB has none and that of group O has both. Blood of group A cannot have antibody A. The blood of group B has antibody A and hence this blood cannot be given in transfusion to a person of that group. Some types of blood are compatible to each other and the others are incompatible. When two types of blood which are incompatible are mixed, there is a clumping of the red blood corpuscles. The clumped blood cells form big masses and will prevent the flow of blood in the capillaries. Thus the patient suffers and may even die. The chart below shows the distribution of antigens and antibodies in the four blood groups :

The blood of O group can be given to persons of the other three blood groups. A man with O group of blood is called a **universal donor.**

Though whole blood is used in some transfusions, it has been found that the use of blood plasma is equally very effective in many cases. The use of blood plasma has certain advantages. It can be dried and transported. Whenever it is required for use, the dried plasma can be mixed with distilled water and transfused. In transfusions of blood plasma, blood matching is not necessary since there are no red corpuscles to cause clumping.

If cells contain antigen	*The group is called*	*Serum will contain*	*Patient can be tranfused with the blood of group*	*Patient cannot be transfused with*
A	A	antibody B	A,O.	B,AB
B	B	antibody A	B,O.	A, AB
A & B	AB	no antibodies	A,B,AB,O. (Universal recipient)	
Neither A nor B	O	both antibodies anti A and anti B	O (Universal donor)	A,B,AB

IMMUNITY

Several diseases of man are caused by bacteria and other microbes. Often the disease causing germs release toxins which are poisonous products. Normally our body is able to defend itself against **most microbes causing diseases.** The skin acts as a very effective barrier to the entry of many microbes. You have learnt that certain white corpuscles of the blood attack and devour bacteria. Sometimes the bacteria may be too many and destroy the white corpuscles.

Many persons are able to resist diseases to a certain extent. It is a chemical reaction in their blood which makes them immune to the disease. The ~~blood~~ of these persons produces certain substances which are called antibodies. These fight the invading organisms. Each kind of antibody can act only against one type of microbe. Different antibodies have different qualities. Some antibodies neutralise the toxins released by microbes. Certain others clump together the microbes which are then easily attacked by the white corpuscles. Some other antibodies dissolve the bacteria.

The substance that causes the formation of antibodies is called **the antigen.** The foreign microbes or the products produced by them may act as antigens.

Part of the antibodies sometimes remains in the blood plasma and quite sometimes this serves to protect the individual from future attacks. We say such persons are immune to that particular disease. The resistance of our body to disease is called **immunity.** If we readily catch a disease we are said to be susceptible to that disease. What is immunity ? It is the power of resisting the disease and not being susceptible to it.

Natural and Acquired Immunity

Some persons are immune to certain diseases from birth. These people are said to have **natural immunity** or inborn immunity. Even when they come in contact with patients suffering from certain diseases they do not get the disease. Again, some people who have once suffered from a disease do not fall victims again during their life time. In some way the body retains a good supply of antibodies which attack antigens during any future invasion. This is **acquired immunity.**

A person can be made immune to a disease by introducing into his body certain serums. The immunity caused in an organism

by such artificial means is known as artificial or acquired immunity. We have all heard of vaccination. When there is an epidemic of small pox the health authorities vaccinate the people. By vaccination an immunity is produced in the person artificially.

Dr. Edward Jenner, an English doctor was the first to discover a safe and effective means of producing artificial immunity against small pox. He had observed that milk maids who contracted cowpox from cows never got an attack of small pox. He wanted to find out whether cowpox infection produced immunity to small pox. He took some fluid from the cowpox sore on the hand of a milkmaid and injected it into the arm of a boy. After some time, he deliberately infected the boy with small pox fluid, but the boy never got small pox, which is otherwise very infectious. The boy had become immune to small pox. The doctor by his experiments had vaccinated the boy. Now childhood vaccination has become compulsory. The scar which you often find on your arm is due to vaccination. In vaccination the host is deliberately infected with a disease organism. The inoculated substance is called a vaccine, which, however, is very diluted or is weakened.

How is the vaccine obtained? A calf is at first infected with small pox virus. The calf gets the disease in a mild form. The virus in the calf becomes weakened. These weakened small pox virus is collected as vaccine and introduced into the human body. Since the virus is weak it is not able to bring about a severe form of the disease in the person. But the presence of the virus, though in a weak form, induces the body to produce antibodies and this gives our body immunity to small pox for at least five years. After that revaccination is to be done to continue the immunity.

You have just learnt that by introducing the weakened microbes inside our body the latter can be made to produce the required antibodies. Such an immunity in which the organism is made to produce its own antibodies is called **active immunity**. It takes sometime before the active immunity is shown. The effect of this will last for a number of years or even a whole life time.

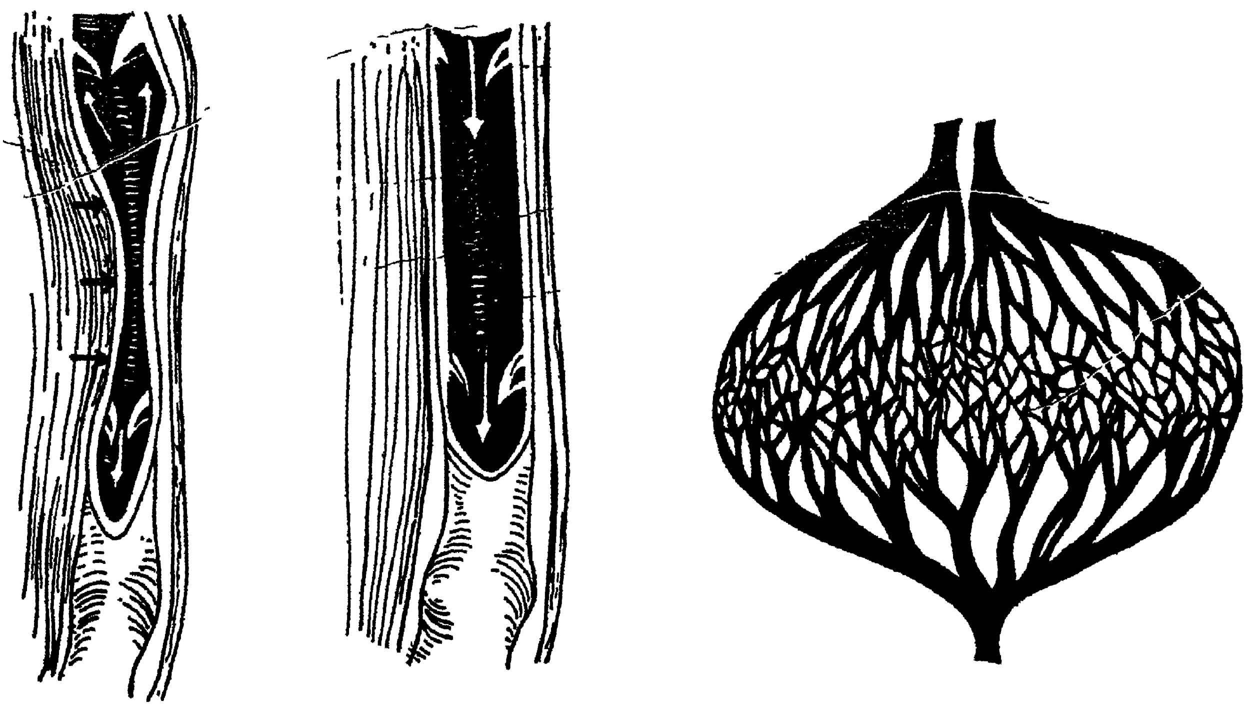
Immunity can also be gained in another way. In such a case, an experimental animal like the horse is infected with the disease producing microbes. The antibodies are produced in its blood of the

horse. The serum of such an animal is extracted and introduced into the human body. The serum contains the antibodies against the particular disease. But these antibodies were produced by the experimental animal and not by the human body. The human body utilizes the ready-made antibodies, introduced into it through the serum to produce immunity. Such an immunity is known as **passive immunity.** The passive immunity is produced immediately after the serum is introduced in an individual. But the effect lasts only for a short period.

Vaccines are now produced to give immunity against diseases like whooping cough, diphtheria, measles, tetanus, typhoid, polio, rabies and tuberculosis. Excepting for measles the vaccines for the above mentioned diseases produce active immunity. Both active and passive immunity is produced for tetanus and diphtheria.

Blood Circulation

In our body the blood is forced outward from the heart through the arteries. These arteries become smaller as they branch out among



a b c

Fig. 5.5 a. and b. show the presence and working of valve in a vein ; c. shows the arteries breaking up into capillaries and uniting to form veins

the tissues. As a result of repeated branching, the arteries end in extremely small blood vessels called capillaries, (Fig. 5.5.). The capillaries pass between cells and thus bring blood into intimate contact with the cells, so as to facilitate exchange of materials. The capillaries join together to form larger vessels. These large vessels are known as veins, through which blood goes back to the heart.

The arteries are generally thick-walled and contain red blood containing plenty of oxygen. The red blood is otherwise known as oxygenated or arterial blood. The arteries carry the blood away from the heart. They supply the blood to the various parts of the body. The veins have thinner walls than the arteries. The veins contain blood which is dark red in colour. This is venous blood or deoxygenated blood. The veins carry the blood containing plenty of carbon dioxide to the heart to be pumped to the lungs. The veins have valves which allow blood to flow towards the heart and prevents a flow away from the heart.

Heart : Its Structure and Functions

You have just now learnt that the blood is contained in closed vessels. How is the blood contained inside vessels, kept moving ? The movement of blood inside the vessels is known as circulation. The circulation of the blood inside the body is maintained by the pumping force given by the heart. The heart is a pumping organ.

The working of the heart and circulation of blood inside the body remained a mystery till William Harvey, a British physician discovered the fact in 1628. In olden days people thought that the heart was a place in the body where love and courage were felt Harvey described the circulation of blood inside the body and the working of heart in maintaining the circulation.

The heart is one of the remarkable organs of our body. It goes on rhythmically contracting and relaxing without any stop. It begins to beat when a person is an embryo inside the mother's body and continues to beat as long as one remains living.

Position and Size of the Heart

The heart is located in the thoracic cavity, more or less on the central line of the body, behind the sternum and a little to the left of

it. The size of one's heart very roughly corresponds to the size of his clenched fist.

Structure

The heart is enclosed in a double-walled sac, the **pericardium.** Between the two layers of the pericardium is a fluid which protects the heart from shocks and friction and renders its working much easier.

The heart is a muscular organ (Fig. 5.6). The muscle which forms its walls is different from the other muscles of the body. Its contractions and relaxations are repeated in a definite cycle. A short period of rest follows each contraction.

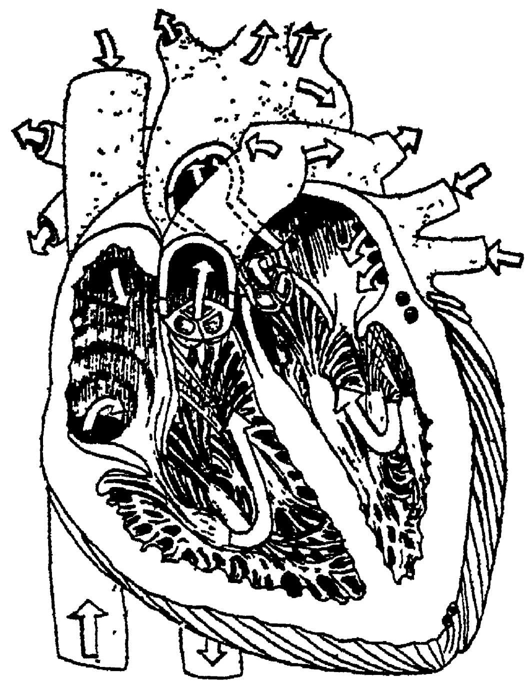


Fig. 5.7 Section of a human heart to show the internal structure

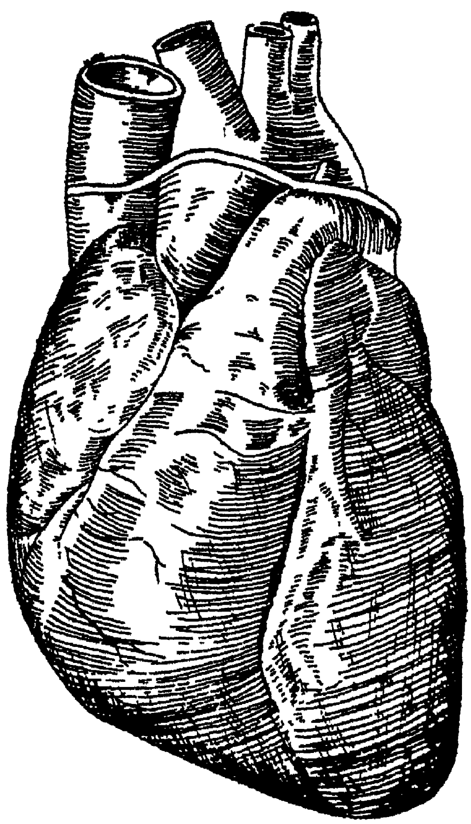


Fig. 5.6 Human heart : external view

The heart is divided into two distinct halves by a muscular wall, the septum (Fig. 5.7). Each side of the heart is divided into two chambers. The one at the top is the **auricle** and that below is the **ventricle.** The auricles are thin walled chambers while the ventricles are thick walled. An auricle of each side communicates with the ventricle through valve. These valves consist of flap-like structures. The valve on the right side of the heart has three flaps. The valve on the left side has two flaps. When the flaps close, the valve shuts tight the passage between the ventricle. These valves open in one direction

only towards the ventricles. When the ventricle relaxes, the valves open and the blood pours freely from the auricle into the ventricle. When the ventricle contracts, the blood cannot flow back into the auricle because the flaps of the valves close up due to the pressure of the blood. Certain thread like structures attached to the flaps prevent them from turning back in the direction of the auricles.

The blood from the ventricles flows into the arteries. The blood is prevented from flowing back by semilunar valves, having the shape of little pockets. These valves are located in the large blood vessels namely the aorta and in the pulmonary artery at the very exit of these vessels from the heart. When there is flow of blood from the ventricles to the arteries, the little pockets of the valves are pressed to the walls of the vessels, thus allowing the blood to pass freely. The blood that flows back fills up the little pockets of the valves which bulge out and completely block the opening of the vessel and thus the blood is prevented from flowing back into the ventricles.

Vessels Entering and Leaving the Heart

Two large veins open into the right auricle, the **superior vena cava** which receives the blood from the upper part of the body and the **inferior vena cava,** which receives blood from the lower part of the body. Four **pulmonary veins,** two from each lung pass into the left auricle. A **pulmonary artery** through which venous blood flows to the lungs, arises from the right ventricle. The largest arterial vessel, the **aorta**, which carries arterial

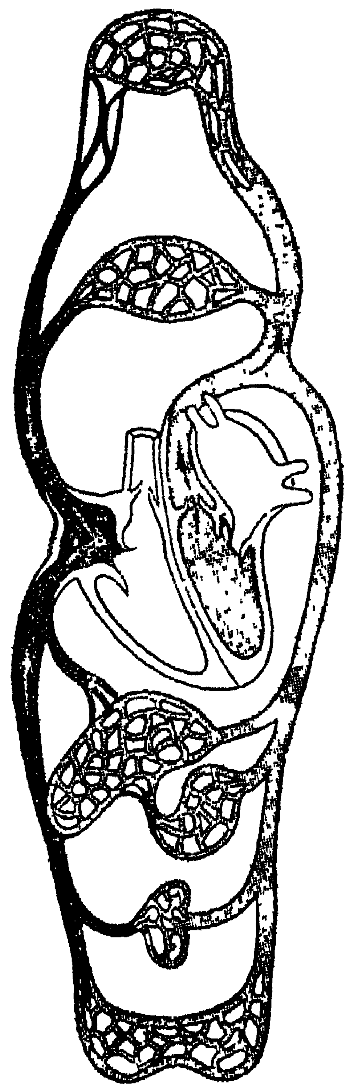


Fig. 5.8 Systemic circulation

blood for the entire body arises from the left ventricle.

The movement of the blood in the blood vessels is known as blood circulation. In the human body as in other mammals there are two circuits of the circulatory system. One of these circuits is large extensive and is known as **systemic circulation** and the other one is less extensive and is known as the **pulmonary circulation** (Fig. 5.9.)

The systemic circulation begins at the aorta. The aorta, after leaving the left ventricle of the heart forms an arch towards the left and runs downwards along the vertebral column. From the arch the aorta sends branches of arteries to the head, neck, shoulder and arms. From below the arch, branches of arteries carry blood to the trunk, and visceral organs. At the pelvic region the aorta branches into two large arteries which supply blood to the legs.

The larger arteries branch repeatedly and end in capillaries. The capillaries join together to become veins. The smaller veins unite to form larger vessels. The venous blood thus brought from the various parts of the body are emptied into the right auricle of the heart by the superior and inferior vena cavae.

The pulmonary circulation begins at the right ventricle. The blood containing carbon dioxide collected and bought from different parts of the body is passed through

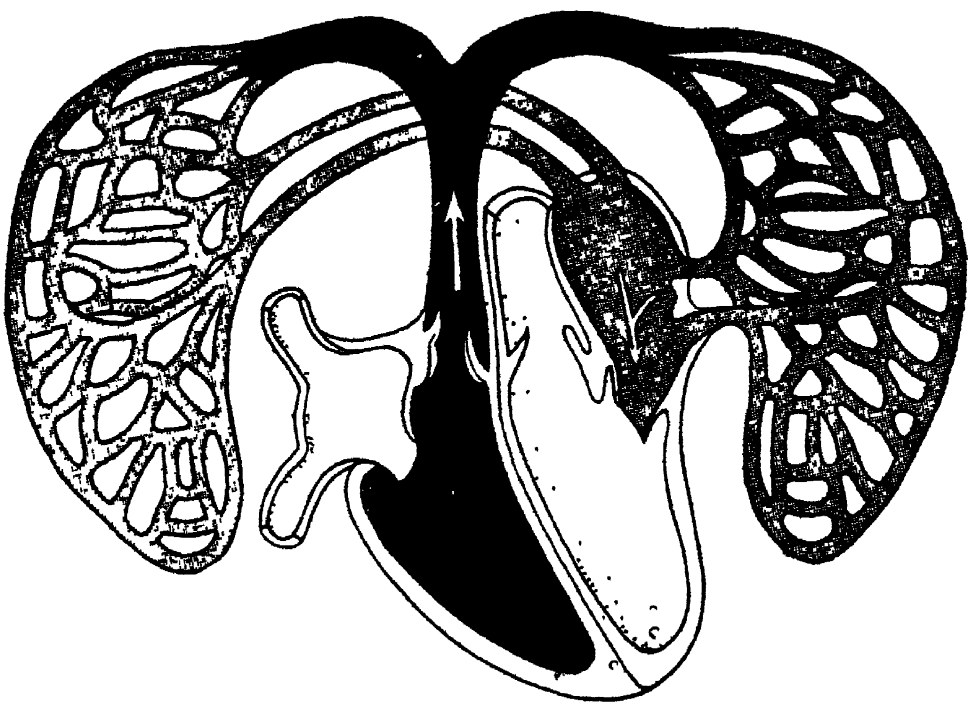


Fig. 5.9 Pulmonary circulatiön

the pulmonary arteries into the lungs. The pulmonary arteries finally break up into capillaries and the capillaries form the pulmonary veins. The blood that has exchanged carbon dioxide for oxygen is brought into left auricle of the heart through the pulmonary veins. This circuit of the blood from the right ventricle to the left auricle is the **pulmonary circulation.**

Action of the Heart

Now you know the structure of the heart and have some idea about blood circulation and its purpose. We must know how the heart works. Place your palm on the chest at a place where you know the heart is, you will feel a regular beating of the organ. You have also seen doctors using a stethoscope while examining patients.

You can also use the stethoscope and listen to the beating heart. You will recognize the characteristic lubb-dubb sound. What are the sounds due to and why are they produced ? It has already been stated that the heart is a pumping organ. Let us see how the heart works.

Observe the working of the heart in a freshly chloroformed and dissected mammal. Note that both the auricles contract simultaneously. Next the two ventricles contract at the same time. After this the whole heart relaxes. During this period the heart gets filled with blood flowing in the large veins. Thus the contractions and the pause during which the blood flows into the auricles constitute the three phases of heart action. Once again the contractions start and we notice a regular periodicity of the contractions with a pause in between. The heart of an adult man contracts on the average 72 times per minute.

Heart Beat

The contraction of the chambers of the heart and the closure of the valves produce distinct sounds. One of the pupils may be asked to place his ear close to someone's chest. The sound is more distinct near the tip of the heart which is inside the chest few centimeteres below the left nipple. This sound produced periodically by the heart is known as the heart beat. The heart of human adult contracts approximately 70-75 times a minute. The heart of a child contracts more often. If you carefully listen to the heart beat, it increases during exercise, exertion or emotion and decreases during sleep or when a person is relaxed. You can make out two kinds of sounds one usually described as 'lubb' sound is caused

by the contraction of the auricles and the ventricles. The other sound is often described as 'dubb' sound. This is caused by contraction of the ventricle and the closing of the semilunar valves at the base of the arteries.

The stethoscope is a device which amplifies the sound, so that a doctor will be able to listen to the clear and loud sounds of the organs like the heart and lungs. From these sounds the doctors are able to infer whether the heart or lungs are working properly. If sounds different from the usual ones are heard, it might be due to certain defects in their working. The doctor can tell from the nature of these strange sounds, the kind of disease from which the person suffers.

Pulse

At each heart beat there is rhythmic expansion of the arteries. This expansion originates at the aorta. It is passed on to all the arteries in the form of a wave. The rhythmic beating of the artery is called the **pulse**. Pulse is felt more clearly in those regions of the body where the arteries are close to the surface of the body. The pulse can be felt in the superficial arteries by pressing them against the underlying bones. We can count the number of heart beats by feeling the pulse. You might have commonly seen the doctors feeling the wrist of the patients. An idea of the number of pulses per minute in a patient helps a doctor in finding facts which are helpful to him in treating the patient. The pulse rate responds with the rate of the heart beat.

Blood Pressure

You have learnt that the circulatory system in man is a closed system. The blood travels through the blood vessels under pressure. The pressure of the blood inside the blood vessels depends on many things like the force with which the heart beats, the amount of blood in the body and the width and elastic nature of the vessel. The blood pressure is the pressure of the blood in the arteries. Blood pressure is highest when the heart contracts (systole) and lowest when the heart is relaxed (diastole). The blood pressure is measured by a special instrument and is expressed as 120/80 the systolic and diastolic pressures respectively. Blood pressure increases with age. But extremely high or low-blood pressure is usually interpreted as a danger signal by the doctors. Therefore the doctor checks the blood pressure of the

patients in certain kinds of diseases. Anxiety and worry, consuming excess of fat and h'ghly nutritive food with no physical exercise are supposed to be some of the causes that result in high blood pressure.

Lymphatic System

As blood flows through the capillaries, some of the clear liquid of the blood oozes out through the capillary walls and enters the spaces in the body tissues. This fluid, called lymph, is found in between the cells of all the tissues in our body. The lymph brings food substances to the cells of the tissues and takes back wastes from them. The excess of this fluid either gets back into the blood or into certain special vessels known as lymphatic vessels. There is a dense

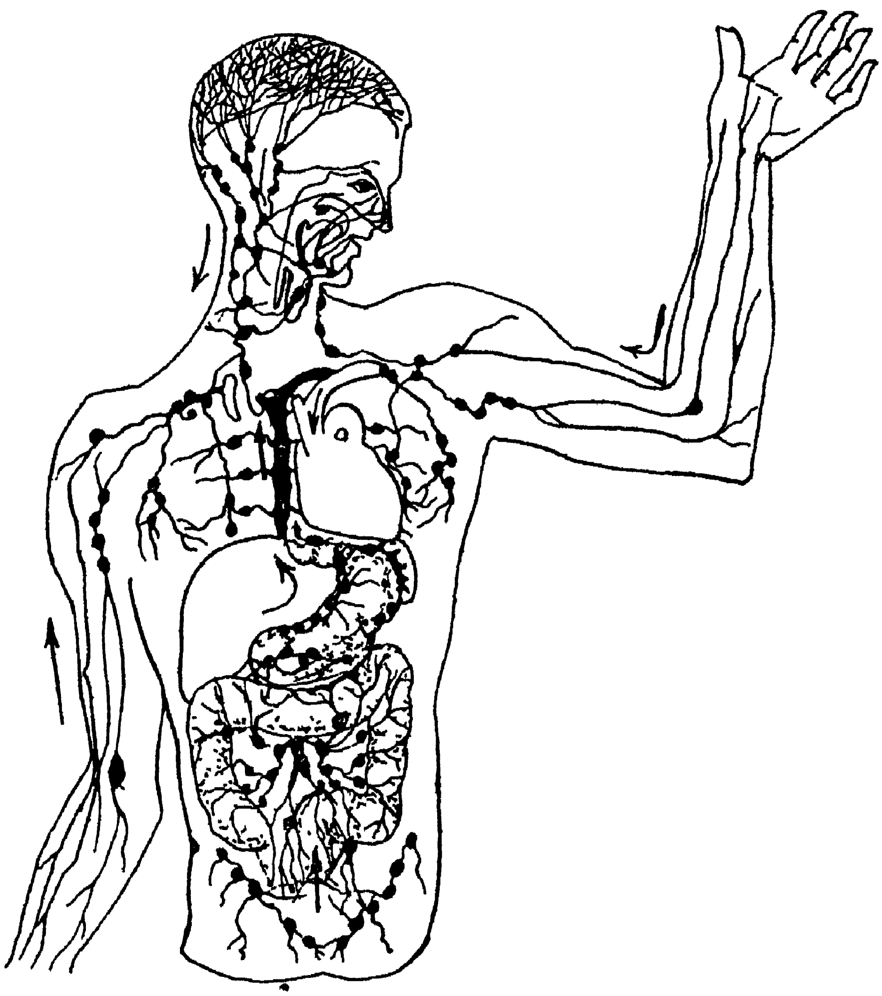


Fig. 5.10 Lymphatic system

network of minute lymphatic in our body (Fig. 5.7). These vessels unite to form two large vessels. These join the large veins pouring the lymph into them.

Smaller lymphatic vessels show certain small swellings known as lymph nodes (Fig. 5.10). Their cells are large and loosely arranged. Large number of new white corpuscles are also found in the lymph nodes. The harmful germs that find their way into the blood are caught retained and finally killed in these nodes. Thus, the lymph nodes act as filters of germs. The nodes also retain various poisonous substances, and render them harmless.

First Aid During Haemorrhage

There is often considerable bleeding in cases of wounds or injuries. Any extensive bleeding whether internal or external is called **haemorrhage.** Bleeding may be from arteries, veins or capillaries. The most serious bleeding is from an artery. The blood spurts out from the injured artery with great force. In the case of venous bleeding, the blood flows out in an even stream without any spurting. In severe case of bleeding there is not enough time for clots to form on the edges of the wound. Even if clots are formed they are immediatly torn off and carried away by the blood stream.

First aid must be rendered in all cases of bleeding. The capillary bleeding can be stopped by bandaging the bleeding part tightly with cotton wool and gauze. In the case of severe arterial bleeding, the artery which brings blood to the injured part of the body must be compressed well with the finger. The points where the most important arteries of the body are to be compressed in cases of bleeding are shown in Fig. 5.11. By feeling these places on one's own body one may learn to locate them quickly and easily.

In order to compress the artery for a prolonged period of time in cases of injury to the arms or legs, a ligature is used in the region of the humerus or femur. A rubber tube or handkerchief or rope twisted may be used as ligatures. To compress the artery better, a tightly rolled gauze bandage or a ball of some clean cloth is inserted under the ligature. A ligature should not be used for more than two hours, since it might harm the tissues.

Clotting of blood is considerably accelerated if the bleeding is first

partially stopped by compressing the artery and then binding it tightly with a bandage. In a case of severe bleeding, the above mentioned first aid measures should be applied and a physician called without delay. In order to lessen the loss of blood from the brain and to facilitate the work of the heart, head of the injured person should be placed a little lower than his body, with the arms and legs raised. Hot water bags should be applied and hot drinks given to keep the patient warm.

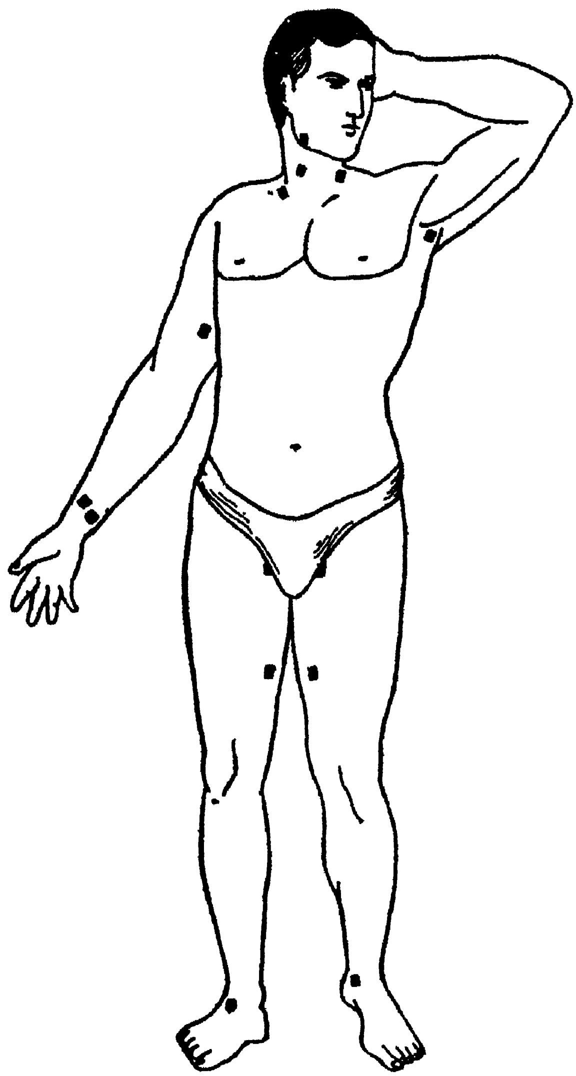


Fig. 5.11 Points where arteries are to be compressed in case of bleeding

Nervous and Chemical Regulation of Cardiovascular System

The working of the heart and the amount of blood that fills the blood vessels are very much influenced by the nervous system and the

varying amounts of chemical substances found in the blood from time to time. The nerves that supply the heart and blood vessels make them work slower or faster according to the surrounding conditions. For example, when it is cold outside the nerves cause the constriction of the blood vessels of the skin. When the weather becomes hot, the blood vessels dilate due to the messages received from the nerves. When our body is subjected to a sudden and extreme cold, as in the case of plunging in cold water the heart may even stop its contraction for a short time.

The cortex of the cerebral hemisphers of the brain exert the greatest influence on the heart and blood vessels.

Of the different chemical substances formed or released into the blood, adrenaline and acetylcholine are of great importance. Adrenaline causes the blood vessels to constrict and thus increases the frequency and intensity of the contraction of heart and dilates the blood vessels.

Effects Of Physical Exercises And Sports On The Cardiovascular System

Whenever we do heavy work, the organs involved in this work require increased blood supply. This increased supply is met with by increasing the frequency of contractions of the heart and thus increasing the amout of blood sent out with each contraction.

In a person who plays games and does physical exercises the work of the heart is increased. More blood is pumped out with each contraction. The frequency of the contractions of the heart in such persons is increased only when very strenuous work is done.

In a person leading a sedentary life the heart intensifies its work mainly by increasing the frequency of its contractions. This increase in the rate of contractions very much reduces the period of contraction of the heart, and with the result the heart is unable to contract fully and pump out all the blood it contains. Gradually the muscles of the heart get weakened and lose the capacity to increase their working capacity.

Playing games and doing physical exercises help to strengthen the muscles of the heart. The degree to which one can do hard physical work depends upon his age and condition of health. A younger person with good health can do greater amount of physical work. If the heart is forced to perform strenuous work that is beyond its strength it quickly becomes fatigued

its contractions become weaker, the amount of blood pumped into the aorta is decreased. Too great a strain on the heart muscle results in stretching them too much and they become flabby.

Effect of Liquor on The Heart

Within two minutes after drinking, alcohol leaves the stomach and enters the blood. The blood carries the alcohol and delivers it to the brain, liver, muscles and other parts of the body tissues. It generally diminishes the activity of the body functions. Among other things it deadens the nerves.

The prolonged used of alcohol results in gradually replacing the muscle tissues of the heart by fatty tissues. The accumulation of fat weakens the heart muscles and decreases the work of the heart, with the result different organs of the body fail to get proper amount of blood.

Summary

Blood is composed of a liquid portion and a solid portion. The liquid portion of the blood is called plasma. The solid portion is composed of the red corpuscles, white corpuscles, and blood platelets. The red colour of the blood is due to the presence of a pigment known as haemoglobin in the red corpuscles.

The functions of the blood are :

1. to transport oxygen, food materials and hormones to different parts of the body,
2. to maintain a constant body temperature and water balance of the body,
3. to protect the body agaist invading germs.

The clotting of the blood is the result of conversion of fibrinogen into insoluble fibrin by a substance known as thrombin.

Human blood is classified into four groups—A,B, AB and O on the basis of the presence of particular kinds of antigens. The existence of these four groups of blood was discovered by Landsteiner in 1900.

The serum contains antibodies. The number of antibodies corresponds to the number of antigens. Indiscriminate mixing of blood might result in clumping of corpuscles known as aggluti-

nation. Persons with O type blood are the universal donors while those with AB type blood are universal recipients.

Immunity is the resistance of our body against the infection of disease causing organisms The immunity against a disease is the result of the production in the blood of certain substances called antibodies. The substances like a germ that cause the formation of antibodies are the antigens. The immunity may be a natural one or an acquired one. As a result of vaccination, immunity is produced in a person artificially. Edward Jenner discovered a safe method of producing artificial immunity against small-pox.

The acquired immunity may be either an active immunity or a passive immunity. In active immunity the organism is made to produce its own antibodies. In passive immunity the serum of an animal containing the antibodies already produced in it is introduced into another organism.

The human heart is a four-chambered muscular pumping organ.

The blood is distributed to different parts of the body by the arteries. The arteries branch and end in capillaries. The capillaries unite to form veins which bring the blood back into the heart. The circulation of the blood can be divided into a systemic circulation and a pulmonary circulation.

The contractions of the chambers of the heart and the closure of the valves produce distinct rhythmic sound known as heart beats. The heart of a normal human adult produces approximately 70-75 heart beats per minute.

At each heart beat, there is a rhythmic expansion of the aorta which is passed on all the arteries as a wave. This rhythmic beating of the artery is called the pulse.

Lymphatics are vessels that carry lymph. Lymph is a liquid derived from the tissue fluid that surrounds all cells.

The cortex of the cerebral hemispheres exert a great influence in controlling the activities of the heart and blood vessels. Adrenaline causes the blood vessels to constrict and increase the frequency and intensity of the heart beat whereas acetylcholine produces the opposite effect.

Physical exercises and games help to strengthen the muscles of the heart and pump out more blood with each contraction.

Prolonged use of alchohol weakens the muscles of the heart.

Questions

1. (a) What are the different kinds of blood corpuscles ?
   (b) What are the functions of each kind of blood corpuscles ?
2. What are the changes that take place in the blood during its clotting ?
3. What is thrombosis ? How is it dangerous ?
4. (a) Which part of the blood is associated with antigens in blood typing ?
   (b) How do two types of antigens produce four blood
5. What is the advantage of using plasma in transfusion ?
6. (a) What is Immunity ?
   (b) How is active immunity different from passive immunity ?
7. List three kinds of blood vessels ?
8. Give a short account of the following parts of our body ?
   (a) Pericardium (b) Ventricle (c) Auricle (d) Aorta
9. (a) What is heart beat ?
   (b) What is pulse ?
10. What first aid would you render in case of haemorrhage ?
11. (a) What is the action of (i) acetylcholine (ii) adrenaline on the heart ?
    (b) How do physical exercise and games help the heart ?

Activities

1. Examine the different kind of blood corpuscles under a microscope.
2. (a) Collect the blood of goat or sheep from a slaughter house and observe the clotting of blood.

(b) Examine a small clot of the blood under the microscope.

3. Mix blood from different persons and observe the clumping of red corpuscles
4. Observe the circulation of blood in the web of frog.
5. Examine the different parts of the heart of a goat or a sheep.
6. Dissect out either a rabbit or a rat to observe the contractions of the heart and the blood circulation.
7. Place your ear on the chest of another child and listen to the heart beat.
8. Feel and count the pulse at the wrist.
9. Observe how a doctor finds out the blood pressure of a patient.
10. Demonstrate the first aid rendered in case of haemorrhage.

CHAPTER VI

Respiration

Our body needs energy to carry out various vital activities. Even when we are resting, some organs like the heart, brain, kidney and lungs keep on working. For this activity also energy is needed. You have learnt in the chapter on 'Food and Digestion' that the energy for our body is obtained from the food we eat. The food materials we eat are converted into simpler substances by digestion so that they could be absorbed and become part of the cells of our body. The energy contained in the digested food materials has to be first released before it is used. The energy is released when the food combines with oxygen. Therefore, oxygen is constantly required. The atmospheric air has oxygen. The respiratory system helps to draw into the body atmospheric air and separate out the oxygen for absorption. Carbon dioxide is formed as a result of oxygen combining with the digested food material that has become part of the cells of the body. The food is oxidised and energy is released during the process. The carbon dioxide so formed is a waste product. This is eliminated.

Breathing and Respiration

The process of taking in of air and giving it out is known as breathing. During breathing there is movement of air. The air from the outside is taken into our lungs and the air from the lungs is expelled. In the lungs the oxygen contained in the air is separated out and absorbed by the haemoglobin of the red blood corpuscles. The oxygen circulated to the tissues of the body breaks down the reserve food resulting in the release of energy and formation of carbon dioxide. The absorption of oxygen and the formation of carbon dioxide with release of energy in a living being during the breakdown of

reserve food is known as respiration.

Respiratory System

The chief organs of respiration in a human body are the lungs. Before air enters the lungs, it has to pass through long passages of different organs. The air first enters into the nose cavity through the nostrils. The nose cavity is separated from the mouth by certain partitions. The cavity is divided into right and left chambers by a cartilaginous partition. The little hairs that are present in the cavity help to filter particles of dust and foreign matter and thus prevent their entry into the lungs. The air in the nose cavity gets warmed and moistened. The sticky surface of the nose cavity catches the fine particles of dust. From the nose the air enters the **pharynx.** The lower part of the pharynx separates into two tubes, the one in front is the windpipe and the one at the back is the **oesophagus.** In the pharynx, there are masses of soft tissues known as **tonsils** and **adenoids.** Sometimes the tonsils and adenoids get infected and enlarged and give trouble.

The air from the pharynx reaches the windpipe. The opening into the windpipe is a narrow slit, the **glottis.** The air entering this opening passes into the box-like **larynx** or the voice box. The larynx is commonly referred to as the **Adam's Apple.** It is larger and prominent in boys than in girls.

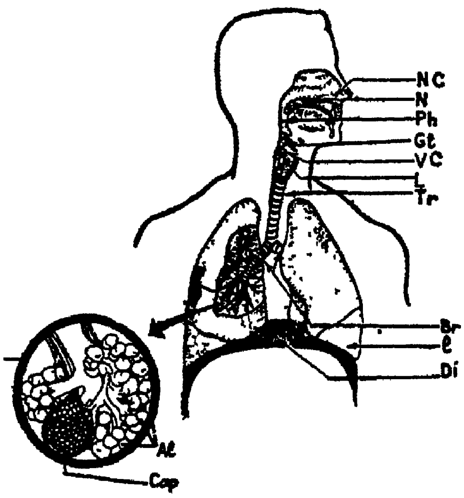


Fig. 6.1 Respiratory system of man : N.C, Nasal cavity ; N. Nose ; Ph. Pharynx ; Gl. Glottis ; V.C. Vocal cords ; L. Larynx ; Tr. Trachea ; Br. Bronchi ; L. Lungs ; Di. Diaphragm ; Al. Alveoli ; Cap. Capillaries

The common passages for both the food and air is the pharynx. After going through this passage, the food gets into the oesophagus and the air into the windpipe. The traffic gets complicated while eating but it is automatic and is regulated into their respective passages. There is an organ called **epiglottis** which closes the opening of larynx when

food is swallowed. However, occasionally, particles of food might start going into the windpipe. But immediately the chocking and coughing that is caused by the entry of the food into the wrong passage expels the food particles.

Inside the larynx there are vocal cords. These are two folds of ligaments stretched across the cavity. Air forced out of the lungs causes the vocal cords to vibrate. The greater the force the louder is the noise. In men the vocal cords are longer than those in women. The high pitch of a woman's voice is due to the shorter vocal cords.

The trachea or the windpipe proper is a tube supported by rings of cartilage. At its lower end it is divided into two tubes, the right and left bronchi. The **bronchi** (singular bronchus) lead into the lungs. The rings of cartilage embedded in the walls of the trachea and bronchi make them elastic and prevent them from collapsing. At the same time they allow air to pass through freely.

The respiratory tract is lined with mucous membrane. Any microbes or small particles of dust that find their way inside the air inhaled are caught and held on the moist surface of the mucous membrane, and the air passing through the respiratory tract is almost free of suspended particles. Moreover the mucous weakens the microbes by diminishing their ability to multiply and weakens their poisonous qualities. Some of the microbes even die. Most of the cells of the mucous membrane, particularly those found in the trachea and bronchi are supplied with a large number of hair-like projections, the **cilia.** The cilia by their constant movement push up the dust particles that have been caught on the sticky membrane. Thus they prevent the particles from reaching the air passages of the lungs.

Air Passages end in the Lungs

Each bronchus divides and subdivides within a lung forming a network of tubes resembling branches of a tree. These smaller sub-divisions are the **bronchioles**. Each bronchiole ends in a tiny chamber—the air sac. From the walls of air sac a cluster resembling a bunch of grapes protrude. These are **known as the alveoli.**

The walls of the alveolar sac consist of one layer of flat cells wrapped around on the outside by a thick network of very minute blood vessels. The exchange of gases between the blood and the air in the lungs takes place in the alveolar sacs through the thin

membrane that separates the blood from the air in the lungs. The exchange of gases takes place by diffusion through the thin membranes of capillaries and the alveoli.

Due to the enormous number of alveolar sacs and their globular structure, the internal absorbing surface of the lungs is tremendous. There are about 300 million alveolar sacs in our lungs. If all the alveoli were flattened out, they would occupy an area of more than 100 square metres.

Lungs

The lungs are cone-shaped. The lower surface of the lungs is concave to accommodate the diaphragm which bulges into the body cavity. The right lung is larger than the left lung. The right lung is divided into three lobes, and the left into two lobes. The lungs are enveloped in a membrane called the **pleura**, which is double-layered round each lung. The space between the two layers is filled with a fluid. The lungs are surrounded by a bony case formed of the breast bone, the ribs and the vertebral column.

Gaseous Exchange in Lungs and Tissues

The atmospheric air which enters the lungs has nearly 21 per cent of oxygen. The air we breathe out contains only about 16 per cent of oxygen. From this we can infer that we utilize about one fourth of the oxygen taken into the lungs. The loss of oxygen in the lungs is compensated by the gain in carbon dioxide in the breathed out air. The air entering into the lungs contains about 0.03 per cent of carbon dioxide. The air breathed out, on the other hand contains nearly 4.5 per cent of carbon dioxide. This additional amount of carbon dioxide is obtained from the blood which comes to the lungs. The nitrogen, which constitutes about 79 per cent of the air remains unchanged during respiration.

Blood rich in oxygen is pumped by the heart to the various parts of the body. The oxygen from the blood unites with substances of the cells and as a result of this energy is released and carbon dioxide that is evolved dissolves in the plasma of the blood and is brought to the lungs for purification.

Breathing Movements

Breathing takes place as a result of the changes in the size of the chest cavity. It causes changes in the pressure allowing the move-

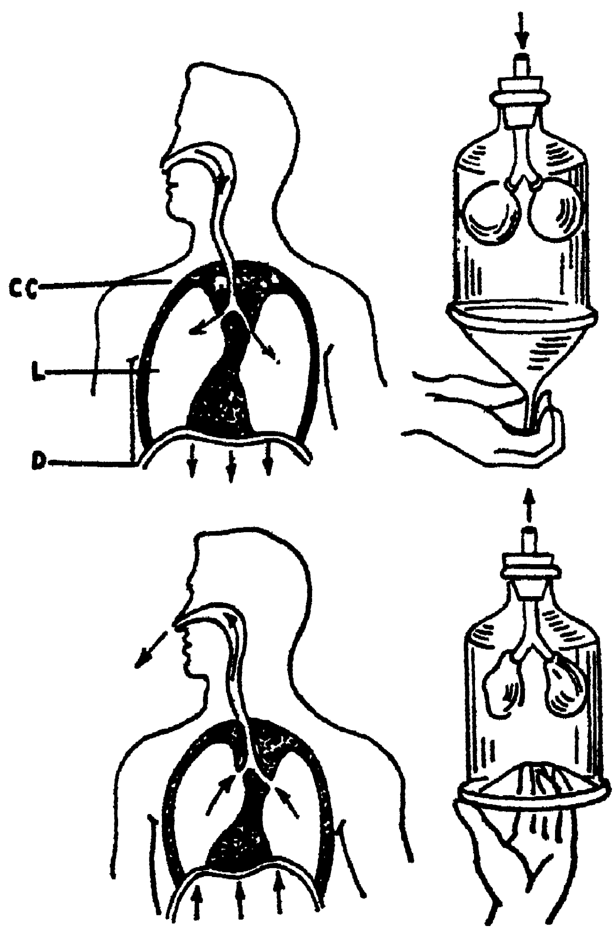


Fig. 6.2 Changes in the chest cavity during breathing : C.C. Chest cavity; L. Lungs; D. Diaphragm

ment of air in and out of the lungs. When you breathe in air, the rib muscles contract raising the ribs forwards and upwards. The contraction of the rib muscles is accompanied by the contraction of the muscles of the diaphragm. As a result the dome shaped diaphragm is pulled downwards and thus gets flattened. These two changes result in an increase in the volume of the chest cavity and consequently lowers the pressure inside and air is let in. When you breathe out air, the rib muscles relax. This brings the ribs to their orignal position. The diaphragm assumes its original dome shape. All these changes increase the pressure on inflated lungs and thus the lungs are squeezed. The lungs shrink and squeeze out air.

When a person lies or sits quietly, he makes 15 or 16 respiratory movements a minute. The rate of this kind of breathing varies with age. A baby breathes about 45 times per minute. At the age of six, it is reduced to 25 times per minute. Each respiratory movement brings about an exchange of a comparatively small part of the air in the lungs, about 500 ml or less.

The carbon dioxide content of the blood also affects the rate of breathing. If the carbon dioxide accumulates in the body, it sends a strong stimulus to the brain. This results in the increased rate of breathing activity. After frequently breathing for some time the carbon dioxide content of the blood is reduced. After frequent breathing the normal breathing is resumed.

Artificial Breathing

The respiratory movements might stop due to certain accidents like drowning and electric shock. In such cases the respiratory movements can be restored artificially. Artificial breathing is done by inducing alternate expansion and contraction of the thorax by applying some force from outside. The person who is rendering aid should take his position at the head end of the patient. Then he should draw the patient's arms upward and backward as far as they can go. The movement of the arms raises the ribs, the thorax expands and draws the air into the lungs. Then the arms of the patient are bent at the elbows at a sharp angle and pressed close to the chest, thus squeezing against the ribs. As a result, the ribs are lowered, the thorax is compressed and the air is expelled from the lungs (Fig. 6.3). The rate of artificial breathing should be the same as in normal breathing, 16-18 movements per minute.

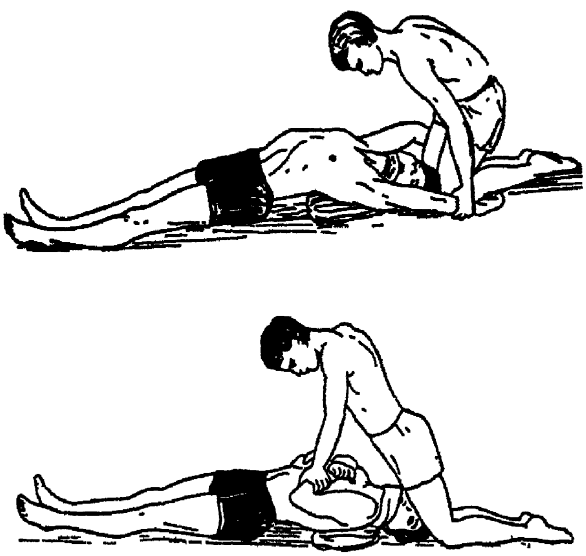


Fig. 6.3 First aid : Artificial respiration

Artificial breathing should be continued without stopping as long as there is evidence of even the slightest activity of the heart. There have been cases where person were brought back to life by this means even after the normal breathing had stopped.

Hygiene of Breathing

Correct Breathing

Correct breathing helps to improve the health and raise the efficiency of working. To develop correct breathing habits the thorax should be properly developed by maintaining correct position while standing, walking and sitting and by engaging in sports and games. A person who has a well-developed thorax breathes evenly and rhythmically. Frequent uneven breathing is supposed to result in lowering the efficiency of mental work. On

the other hand, the normal, quiet breathing makes one to concentrate properly in his work and thus increase the efficiency of work. A normal rate of breathing can be maintained only by breathing through the nose. You have already learnt that the air drawn in through the nose gets easily warmed up and rids itself of particles of dust and of microbes.

Ventilation and Healthy Surroundings

Fresh outdoor air is good for the body, while the air in unventilated room is harmful. The air in closed rooms contain plenty of carbon dioxide, dust particles, vapour and other gaseous products. People who spend much of their time in poorly ventilated rooms and very little out of doors become anaemic and get fatigued quickly.

The fresh air from outside should be constantly let into the rooms where people work and live. To constantly renew air, special ventilation systems are installed in places where many people gather as in theatres and factories.

Living rooms should be kept as far as possible free from dust. Before entering a room one must carefully get rid of the dirt on one's feet so as to avoid carrying dust from the street into the room. In cleaning a room, one should try not to raise dust. The floor should be swept with a damp broom or with a brush wrapped round with a damp cloth.

Deep Breathing

After each normal expiration, about 3000 ml of air remain in the lungs. While inspiring normally, a person draws in about 500 ml of air of which only 300 to 350 ml reach the alveolar sacs, the balance of 150 ml remain in the respiratory tract. Such a pulmonary ventilation involving only about 350 ml of air is not always enough. For doing work enormous amount of energy is required by the body. For the liberation of this energy, there is a great need of oxygen. The liberation of this energy also results in the formation of great amount of carbon dioxide. The increased supply of air to the lungs can be met in two ways : by increasing the rate of breathing and by intensifying each respiratory movement. If the rate of breathing is increased, the breathing becomes so shallow that only a small portion of air enters the alveolar sacs. Therefore, deep breathing is the best way for ventilating the air in the lungs and in helping to intensify the gaseous exchange.

Vital Capacity

A change in the volume of the chest cavity depends on depth of the breathing. In quiet breathing the chest cavity changes very little in volume ; in deep breathing, one can draw several litres of air into the lungs. The quantity of air which one can inhale at the end of the deepest expiration or the quantity which one can expire after the deepest inspiration is known as the **vital capacity** of the lungs. It averages 3,500 ml. The vital capacity of the lungs to a large measure depends on training, age and sex. An instrument known as the **Spirometer** is used to measure the vital capacity of the lungs.

Harmful Effects of Smoking

Many persons have acquired the habit of smoking. Many of the smokers are not fully aware of the harmful effects of smoking. As a result of smoking a substance known as nicotine present in the tobacco is absorbed into the body. This nicotine is highly poisonous substance. This nicotine affects the nervous system, blood vessels, digestive organs and lungs in various ways. Prolonged smoking impairs the efficient functioning of various organs and makes them vulnerable to diseases.

Smoking which results in the irritation of the throat might lead to cough and other forms of infection of the respiratory tract.

In recent years evidence has been gathered to prove that heavy smoking causes cancer of lungs. Incidence of cancer is rare among non-smokers. A kind of tarry substance known as **tobacco tar** was proved in certain experimental animals to induce cancer when their skins were coated with it.

Air Borne Diseases

The air acts as a medium in the spread of certain diseases. When one coughs, sneezes or speaks, little droplets containing microbes of various contagious diseases are expelled into the air. Such droplets usually remain suspended in the air for sometime and readily find their way into the respiratory organs of other people. Diptheria. whooping cough, measles and influenza are some of the diseases that are spread in this way.

Dust is also a carrier of contagious disease. While cleaning up a room or brushing clothes, particles of dried up saliva, phlegm, and pus get into the air and do not settle for a long time. Some contagious diseases like tuberculosis are also contracted in this way.

Tuberculosis is one of the most

widely spread infectious diseases. It is caused by a kind of bacteria. Tubercular bacteria are capable of multiplying very quickly in the human body. Outside the human body, they remain alive and active for long, if the surroundings are warm and damp. Sunlight kills them in the course of a few hours. They are also killed by boiling.

In most cases tuberculosis affects the lungs. The symptoms of this disease in the initial stages are loss of appetite and weight, fatigue, rise in the body temperature, sweating and a light cough. When the disease reaches an advanced stage, patients suffer from continuous painful coughing, steady and rapid loss of weight and appearance of blood in the sputum. Tuberculosis sometimes affects the vertebral column, joints, skin, and even the brain. Tuberculosis of the vertebral column and joints are quite frequent among children. When the vertebral column is infected, it might lead to the curvature of the backbone. The infection of the joints might lead to the crippled condition of patients if treatment is not given at the proper time.

Even severe forms of tuberculosis can be cured. But detection of the disease at its earliest stage will ensure complete and successful treatment of the disease. The initial symptoms of this disease like loss of appetite, the tendency to get tired easily, rise in temperature, pain at the joints and other skeletal parts, should not be neglected.

Tuberculosis can be contracted by direct contact with the source of infection. Thus, for example a person may be infected by using dishes, the towel or the handkerchief of a patient or by inhaling air contaminated by an infected person. Since the sputum is the main source of infection, it is of the greatest importance that a patient should spit his sputum in closed spittoons ; he should cover his mouth with a handkerchief when sneezing and coughing and he should have a separate bed and towel, separate dishes and should never kiss children.

A kind of vaccine known as BCG vaccine produced from cows is found to be effective in preventing to some extent the infection of tuberculosis in human beings. Even if one gets an infection of tuberculosis after the vaccination of BCG, it would be of a very mild type.

Summary

Breathing involves two processes inhalation and exhalation. Inhalation is taking in of air and exhalation is giving out of air. Respiration is a process by which energy is released in the cells of the body.

The respiratory system includes nostrils, nose cavity, pharynx, epiglottis, glottis, trachea, bronchi, bronchioles and alveoli of the lungs.

The lungs exchange oxygen for carbon dioxide. The oxygen required by the cells for respiration is brought to them by the blood.

Inhalation is an active process in which the rib muscles and diaphragm contract resulting in increasing the volume of the lungs. Exhalation is a passive process of squeezing out the air from the lungs.

Correct breathing habits through nose and deep breathing helps to improve health and the working capacity of our body.

Smoking is harmful to the lungs and certain other parts of our body. Heavy smoking is suspected to produce cancer.

Certain infectious diseases are contracted through the air, the most dangerous being tuberculosis. Tuberculosis can be prevented by leading a hygienic life and by having BCG inocculation. Tuberculosis can be cured ; early diagnosis and treatment might ensure complete recovery from the disease.

Questions

1. How is respiration different from breathing ?
2. Explain the movements that lead into the inhalation and exhalation of air into and from the lungs.
3. What are the chief rules of hygiene of respiration ?
4. What precautions would you take to protect yourself from the attack of influenza and tuberculosis ?

Tasks

1. Study the respiratory organs of a sheep.
2. Find out the presence of carbon dioxide in exhaled air.
3. Demonstrate the mechanism of inhalation and exhalation with the help of a model.
4. Demonstrate the methods of artificial breathing.
5. Read about tuberculosis.
6. Count how many times per minute you exhale air in the morning, after morning exercise, in the afternoon after preparing home tasks and after running for a few minutes. Explain why the rates are different.

CHAPTER VII

Metabolism

What is Metabolism ?

Metabolism is the sum total of all the chemical changes that take place in the organism. For example, metabolism includes the digestion of food materials, transport of oxygen and nutrients to the various parts of the body, liberation of energy, elimination of waste products, and a host of other chemical changes. Metabolism is a continuous process. It is very necessary for the existence of the organism. If metabolism stops all other life functions will cease and the organism will die.

You have learnt in the previous chapters that the digested and absorbed food materials are taken to the various tissues of our body, and the cells composing them absorb these materials. Materials that get into a cell of the body, are not simply collected and stored there. They undergo complex changes and are converted into the substances of the cell itself. This ability of the cells to convert the substances and to utilize them for building up their body parts is called assimilation or **anabolism**. In the process of assimilation or in other words in the process of the formation of living matter, the cells acquire new material and gain in energy content.

At the same time as anabolism is going on, a partial breaking down process is also taking place. The break down of material in the living cell is called dissimilation or **catabolism**. In the process of break down energy is released and one form of energy is converted into another. When a muscle contracts the energy stored up in the muscles is converted into mechanical energy to lift a load and also into heat energy. Thus **metabolism** includes, anabolism and catabolism. Both these processes go on incessantly and simultaneously with each other. Youth is a period of life when anabolism is the characteristic process; middle age is represented by a balance between the two and old

age is a period in which catabolic processes are dominant.

Enzymes and Metabolism

The chemical processes that occur in the human body are due to the action of the **enzymes.** You have learnt how the enzymes help in digesting various kinds of food materials and also for other chemical reactions inside the body. Some enzymes, for example, help in releasing energy and certain other enzymes help in converting one kind of substance into another. The enzymes are produced by the activity of the living cells. The enzymes themselves are products of metabolisms. The participation of enzymes in all the processes of metabolism is absolutely necessary. Without enzymes life is impossible.

In the chapter on "Food and Digestion" you have learnt that the digested fats, proteins and carbohydrates are absorbed by the "villi" of the small intestine. What happens to these food materials?

Metabolism of Fats

Fats are broken down into simpler products, glycerol and fatty acids in which form they are absorbed, However, inside the cells of intestine "villi" these substances are further converted into molecules of fat. There are different kinds of fats in food. Thus animal fat differs from the vegetable fat. The fats formed in the cells of villi are of the same kind as found in the human body. The absorbed fat enters the lymph and from there it is carried by the lymph vessels to the blood circulatory system. It is distributed to all the organs and tissues. The excess fat is stored in the cells of the fatty tissue under the skin.

Metabolism of Carbohydrates

Carbohydrates are absorbed into the blood in the form of simple sugar, **glucose.** Excess sugar is converted into animal starch or **glycogen** and stored in the liver and muscles. The amount of carbohydrates stored in the human body does not exceed 500 to 600 gm. When there is a need for sugar by the body, a small part of the glycogen is again converted into glucose and sent to the blood stream to be used up by the tissues of the body.

Metabolism of Proteins

The end products of digestion of proteins are **amino acids,** which are absorbed through the walls of the intestinal canal and passed into the blood. The blood brings them to all organs. The protein foods are of different kinds.

The difference between the pro-

teins of different organisms is due to the different combinations of about 20 different amino acids to form particular proteins.

When the organs work the proteins are also used as fuel and are oxidized releasing energy. This break-down of proteins is also by the action of enzymes.

As proteins are consumed, they must be supplied constantly along with other foods. When a body is young, its need of proteins is greatest. This is because the body is growing continuosly. The body does not store proteins. It is either broken down and removed or converted into carbohydrates and fats.

Vitamins

The Importance of Vitamins

In addition to carbohydrates, proteins, fats, mineral salts and water, animals and man need certain substances, collectively known as **vitamins**. When sufficient amount of vitamins are not available, there is a decline in the activity of the organism, disorder in its metabolism, frequent fatigue and a general weakening of the whole body. Apart from these, insufficiency of vitamins in the food often leads to diseases known as **deficiency diseases**. Rickets, scurvy and beriberi are some of the diseases.

The chemical nature of vitamins remained unknown for a long time. It was so because even the foods that contain them have them in very minute quantities. Moreover, most vitamins are unstable substances. Many vitamins decompose either partially or completely when subjected to a high temperature or kept for a prolonged period of time.

Most of our knowledge of vitamins has come within recent years. The scientists have succeeded in obtaining pure forms of the vitamins and study their nature. They have also found that the enzymes and certain other substances which are very important for the maintenance of normal metabolism, were produced out of some vitamins in the body. In recent years vitamin pills, capsules and other preparations have become common in the market. They have a very important use in the treatment of deficiency diseases and in supplying the required amount of vitamins for the normal metabolism of the body. You may be aware that the vitamins are of various kinds and are known by the alphabets A,B,C,D, etc.

Vitamin A

The lack of this vitamin affects

vision in dim light. This disease in extreme cases might lead to blindness. Apart from this, severe vitamin A deficiency might lead to weakening of the mucous membrane. The resistance of the mucous membrane to disease is lowered and might result in infections of eyes, the mouth and the respiratory passages. In children the insufficiency of this vitamin might lead to stunted growth, retardation in the formation of bones and teeth.

Shark liver oil contains plenty of this vitamin. Liver, butter and the yolk of egg are rich in vitamin A. A substance that gets converted into vitamin A is found in yellow vegetables like carrots. When this substance gets into the body it gets converted into vitamin A.

Fig. 7.1 Foodstuffs that contain vitamins

Vitamin B

What was considered as one vitamin, namely vitamin B, is now known to be a group of nearly dozen related vitamins. Therefore they are now called as vitamin B-complex.

Some of the vitamins of this group serve as source for the formation of certain enzymes. A lack of this kind of vitamin in food or an insufficient amount of them brings about a serious breakdown in the organism.

In certain parts of our country where rice is the principal food, people are found to suffer from a disease known as **beri-beri**. This disease causes a general weakness in the muscles and paralysis. The patient suffering from this disease may finally die. The cause of the disease is the lack of one of the vitamins of this group. This vitamin is found in the embryo of grains and in the thin covering of the seed. When rice is polished the embryo rich in vitamins is lost along with a layer of covering of the grain. Hence polished rice does not contain vitamins. Our body stores only a small amount of this vitamin. Therefore the supply of this vitamin to our body should be kept constant.

Vitamin B complex is also found in the grains, in nuts, in fruits of leguminous plants, in cabbage, carrot, eggs, liver, milk, green vegetables and yeast.

Vitamin C

The lack of vitamin C leads to a disease known as **scurvy**. Scurvy in its mild form shows the following symptoms; aching joints, bleeding gums and skin bruises caused by even slight pressure. In a severe form of scurvy a patient might suffer from painful swelling of the tongue, loss of teeth, painful swelling of the joints, bleeding gums and blackened lips.

Vitamin C is found abundantly in fruits like oranges, lime, lemons, tomatoes and leafy vegetables. This vitamin is easily destroyed by cooking. Therefore, it is necessary to include raw fruits and vegetables in the diet.

Vitamin D

This is an interesting vitamin. It can be produced by our skin in the presence of sun light. Therefore this vitamin is sometimes called 'sun shine vitamin'. For children, this vitamin is essential for the development of strong bones and teeth. Lack of this vitamin leads to a disease known as **rickets**. The symptoms of this disease in a child are weak and bowed legs, pigeon chest, enlarged joints and protrud-

ing abdomen. The lack of this vitamin in adults results in the loss of calcium and phosphorus from the bones and this increases the danger of fractures.

Shark liver oil, liver and eggs are good sources of this vitamin.

The Role of Liver in Metabolism

Sometimes the liver is called the central laboratory of our body. It is a vital organ in which certain important changes of proteins, fats and carbohydrates take place. The liver plays an important role in carbohydrate metabolism by converting the excess of glucose into an animal starch—glycogen—and storing it inside. When the level of glucose in the blood falls down, the glycogen stored in the liver is reconverted into glucose and sent into the blood in required quantities. Thus the percentage of glucose is always kept constant. If the food of a person consists mainly of proteins the product of digestion will be plenty of amino acids. The excess of amino acids is converted into carbohydrates in the liver. The carbohydrates are converted into fats. Therefore you might find that in certain organisms fat accumulates in its body even though its food consists of a great amount of carbohydrates and proteins and very little of fat.

During the process of metabolism, certain substances which are injurious to the organism are always formed. Many of these substances are changed in the liver and rendered harmless. For example, one of the substances formed as a result of protein metabolism is ammonia. Ammonia is a poisonous substance and therefore it is converted into harmless urea which passes into blood and later eliminated with urine.

Energy Liberation and Energy Utilization

We have learnt earlier that digested food substances are absorbed and used to build up substances of the cells. But these substances are not accumulated endlessly. They are also burnt in the process of oxidation and energy is released.

The proteins, fats and carbohydrates contain energy stored in them. But the amount of energy stored is different in different substances. Experiments have shown that one gram of fat when oxidised yields 9·3 calories. One gram of protein and one gram of carbohydrate each yield 4·1 Calories. What is a calorie ? **A Calore** is the amount of heat required to raise the temperature of 1 kilogram of water by one degree centigrade. The **Calorie** is used as the unit of

heat energy liberated when food is oxidised in the cells.

The caloric content in the diet of a person should correspond to the amount of energy expended by him. Therefore, to determine the daily caloric requirement of a person, we should know how much energy is expended by him every day. There are special methods for finding out this. One of these methods is based on the principle that all the energy expended by the organism is finally turned into heat, in which form it can be determined and measured in Calories.

The daily requirement of Calories by a person depends to a very great extent upon the living conditions, the kind of work done, the weight of the body, the state of health and many other things. If a person lies quietly without any motion whatever, he would expend one Calorie per hour for each kg of his body weight. Taking an average weight to be 50-60 kg this would make a total of approximately 1200-1400 Calories per day. The energy expended by the organism in this state is called **basal metabolism.** A person who does little physical work and leads a sedentary mode of life needs one and a half times more energy. The amount of energy needed in physical work generally rises in proportion to the number of muscles taking part in the movements of the body. Thus a labourer involved in manual labour requires about 3000-35000 Calories.

Nutritional Deficiency

The daily requirements of Calories indicate the daily expenditure of energy by your body to do work and to keep the various organs of your body working. If this much of nutrition is not provided to the body, energy will be drawn from the reserve food material that is kept stored in the cells of the body Therefore the body will gradually lose weight. 30-40 per cent loss of original weight might result in the death of a person from hunger.

Caloric need is only part of the role of nutrition. Food is required not only to meet the daily expenditure of energy, but also for the growth and repair of the body parts. Without this additional food the body will not grow properly. The body might remain weak and might not be able to resist the attack of harmful microbes.

Therefore for normal nutrition, it is necessary that the food should contain sufficient quantity of all the three types of nutritive materials : proteins, fats and carbohydrates. If a person confines himself to an exclusively carbohydrate and fat

diet, completely devoid of proteins, he would inevitably die. Proteins are those building materials without which the cells cannot restore their daily losses.

The body of children grow and increase in weight rapidly. Since proteins are responsible for building the body, they should be present in greater amount in the food of children. The growth of bones and teeth take place rapidly in children. Therefore mineral salts and vitamins should also be present in sufficient quantities in the diet.

Endocrine Organs

The **endocrine organs** are generally small and are found in various parts of the body. Though they are small, they profoundly influence the activity of various organs and tissues through the chemical substances secreted by them. These chemical substances are called **hormones.** Because of their secretory activity these endocrine organs are also called **glands.** You know some of the glands in our body. For example, salivary gland is one. But there is an important difference between the other glands and the endocrine glands. Saliva secreted by the salivary gland, passes from a gland into your mouth through a thin tube or duct. But endocrine glands have no ducts leading from them. That is why they are also called **ductless glands.** These glands pour their secretions or hormones directly into the blood stream. These hormones are the chemical regulators of our body. There is another kind of regulator. This is the nervous system about which you are going to study in the next chapter.

One peculiar feature about hormones is that they should be present in the blood just in sufficient quantities. If more is found in the blood, it leads to certain abnormality and on the other hand, if a lesser amount is present, it leads to certain other kinds of abnormalities.

The knowledge about the functions of the various endocrine glands were gained by experimenting with animals. If a particular endocrine gland is partly or completely removed from an animal, the resulting changes in its body show what the hormone normally does. For example, if such an animal shows a deficiency disease, it may be presumed that the absence or insufficient amount of the hormone in the blood has caused the disease.

It can be tested by giving the animal extracts of the removed gland. If the animal shows recovery from the disease it is a good indication that the absence or insufficiency of the hormone was responsible for the disease. The results of the overactivity of a hormone can be shown by injecting into normal animal, extracts of an endocrine gland. Changes in the body activity of the animal indicate the role of excess of this hormone.

The location (Fig. 7.2), structure and functions of some of endocrine glands are given below.

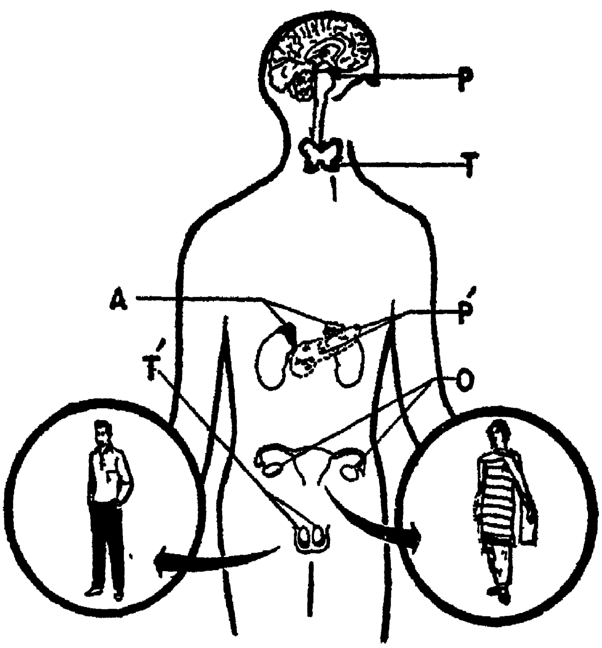


Fig. 7.2 The location of endocrine glands. in the human body. P. Pituitary. T. Thyroid A. Adrenals; P'. Pancreas; O. Ovaries; T. Testes.

Thyroid Gland

The thyroid gland is dark-red in colour and lies in the neck along the larynx. It generally resembles the letter 'H'.

Overactivity of thyroid gland : The thyroid hormone sets the pace of the general rate of activity. Overactivity of the thyroid gland produces many symptoms that are the result of increased activity of the cells. The body oxidises food too rapidly and may oxidise its own tissues. Loss of weight and excess of appetite are some symptoms of thyroid overactivity. There is less of energy available to perform usual work since energy is used up very quickly. The heart beats faster. Restlessness, nervousness, dizziness and difficulty in sleeping are experienced. In some, the eyes bulge out and the person appears to stare.

Underactivity of the thyroid gland : When the thyroid gland is underactive, the body cells do not oxidise the food fast enough. The food accumulates in the body as fat. The patient becomes sluggish and slow, his hand and feet remain cold constantly.

Sometimes there is complete or partial inactivity of the gland. Children suffering from the deficiency are stunted in growth. The face swells, the lips enlarge and the tongue becomes thick and sticks out of the mouth.

If such a condition prolongs for long, the children turn into deformed idiots, incapable of performing any work. They usually do not live long and die when quite young.

If thyroid stops working entirely during adult life, the face and body get swollen, the person loses all interests in things, his memory becomes weakened and the mental activities greatly diminish.

A swollen condition of throat results when thyroid gland becomes enlarged. One of the constituents of the thyroid hormone is iodine. The slight amount of iodine found in drinking water and food is usually quite sufficient for the normal functioning of the gland and formation of the hormone. Sometimes people living in certain localities do not get sufficient amount of iodine.The thyroid gland reacts to this lack of iodine by increasing its own activity.

Pituitary Gland

The pituitary gland is located at the base of the brain. A number of hormones which regulate the various processes of metabolism, are produced by the pituitary gland. This gland influences very much the working of the other endocrine glands in the body. Therefore it is called the master gland.

Underactivity of the pituitary gland:

One of the hormones of the pituitary gland affects the growth of children, especially the growth of their bones. When pituitary gland is deficient in secreting the hormone, growth is retarded. Sometimes the retardation is so great that the patient on reaching the adult stage may not measure more than 70-80 cm in height, which is just half the height of a normal person. Such people are dwarfs (Fig. 7.3).

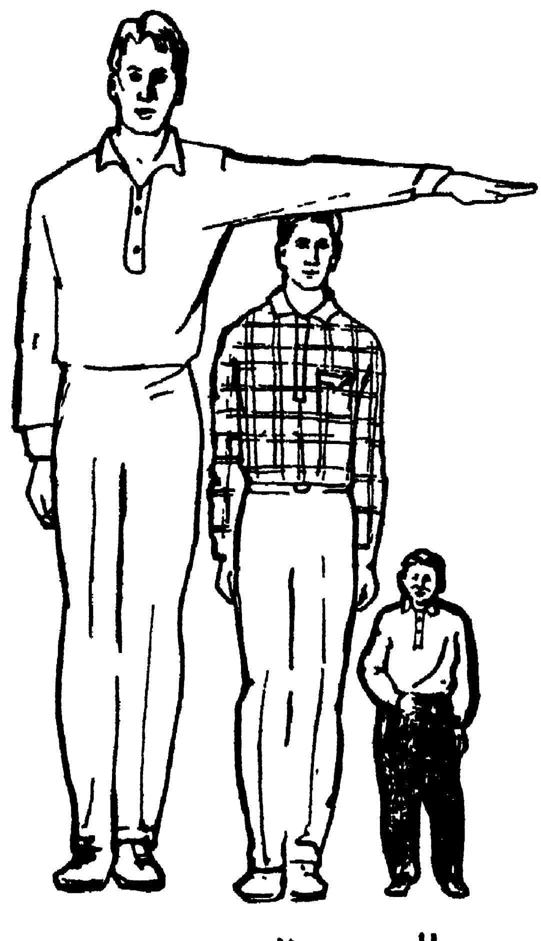


Fig. 7.3 Results of underactivity and overactivity of pituitary gland : O Overactivity ; N. Normal ; U. Underactivity

Overactivity of the pituitary gland : If the pituitary gland is overactive, a reverse phenomenon may be observed. The child begins to grow abnormally fast and assumes giant like proportions of 2-2.5 metres or more in height. Inspite of their great height such giants are not stronger than normal people, sometimes they are even weaker.

If the overactivity of the pituitary gland occurs after a person has become an adult the results are different. Instead of the whole body growing large, certain organs like the legs and arms become abnormally long, the throat swells out and the bones of the lower jaw and the nose become enlarged.

Pancreas

The pancreas serves a double purpose. Most of the cells of the pancreas secrete digestive juice. But there are certain cells that are scattered among the other cells of the pancreas. These scattered cells are organized as tiny islets, known as **islets of Langerhans.** They secrete the hormone **insulin.**

Insulin regulates the amount of sugar in the blood. If the pancreas does not secrete sufficient amount of insulin, the liver and the muscles lose their capacity to hold glycogen. As a result more and more of glucose enters into the blood stream. Excess of glucose in the blood is eliminated along with urine. This condition is known **diabetes.** This is the reason why doctors test urine of patients suspected to be suffering from diabetes. The urine of a normal person does not contain any sugar. Diabetes can be treated by injecting insulin into the body. Insulin is extracted from the pancreas of animals.

The overactivity of the pancreas releases excess of insulin into the blood. This excess of insulin prevents the sugar stored in the liver from getting released into the blood.

Excretion of Waste Products

As a result of oxidation of proteins, fats and carbohydrates, carbon dioxide, water, urea, sulphates, phosphates and other products are formed as the end products. Except water all these other substances are waste products. They are not useful to the body. On the other hand, they might prove harmful to the body, if they are retained for long. Therefore, they are to be thrown out of the body. The cells eliminate the waste products into the medium surrounding it,

that is, into the lymph of the tissues. From the lymph they pass into the blood. The products of metabolism that accumulate in the blood are gradually discharged outside the organism. In our body, this is done chiefly through the urinary organs. However, some of the products of metabolism are eliminated by other organs. Carbon dioxide is eliminated through lungs. Excess of water is given off through skin in the form of perspiration. Salts and certain other products escape through the skin together with water. The functions of the excretory organs prevent the products of metabolism from accumulating in the organism, and at the same time help to keep the composition of the blood constant.

Structure of the Kidneys and their Functions

Two kidneys are located against the wall of the body cavity one on either side of the vertebral column at the level of the waist (Fig. 7.4). Each kidney is a bean-shaped organ about 12 cm long. To understand the structure of a kidney, obtain a section of kidney of sheep.

You will find an outer dark and an inner light layer. Examine the outer layer with a magnifying glass. A large number of dark little dots may be seen. These are little bunches of capillaries. These are parts of the microscopic **nephrons** of which each kidney is composed. In a kidney there are more than one million nephrons. Each nephron is

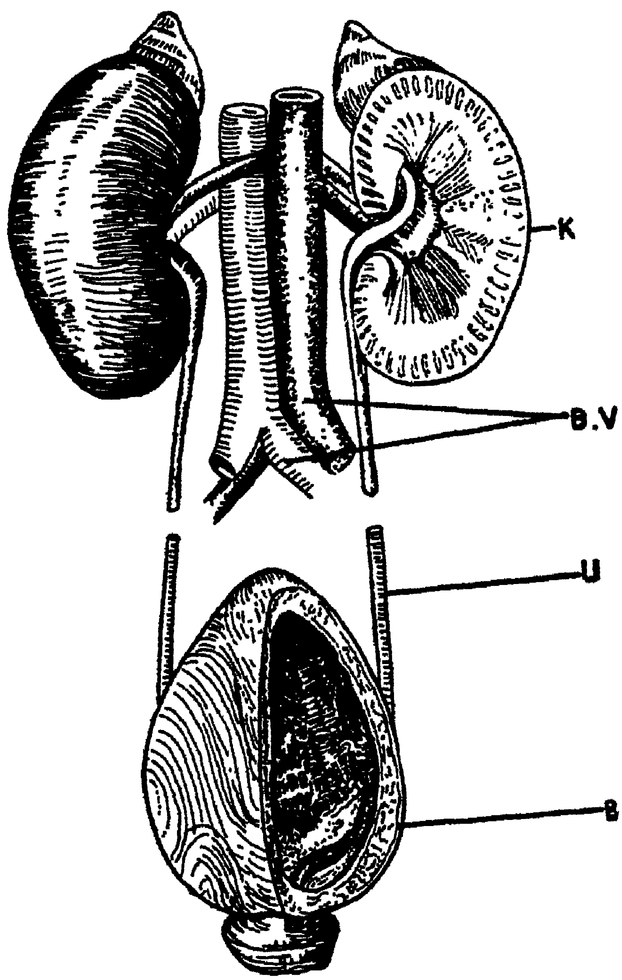


Fig. 7.4 Excretory system of man : K. Kidney ; B.V. Blood vessels ; U.Ureter B.Bladder.

made up of two major parts, a long tubule and a bunch of capillaries known as **glomerulus**. The glomerulus is enclosed by the enlarged part of the tubule. The tubules unite to

form water ducts which pass through the inner layer of the kidney and terminate in a cavity inside the kidney. The excretory products formed by the kidney are conducted into the **bladder**. The bladder is situated in the lower part of the body cavity. It has a thick muscular wall and can be compressed when its muscular wall contracts.

Two large blood vessels are associated with the kidneys. One of these supplies blood to the kidneys and the other carries the venous blood from the kidneys. The kidneys are organs of excretion. They excrete urine. Urine consists of water, salts, urea and uric acid in solution.

The formation of urine begins in the glomeruli. Here the liquid part of the blood filters through the capillaries into capsules. From the capsules the liquid passes into the tubules where it undergoes considerable changes. All the sugar and protein contained in the liquid is absorbed by the cells of the tubules and passed back into the blood. Several other substances like water are also partly absorbed back into blood. As a result, liquid in tubule becomes more concentrated. In its passage through the tubules the liquid gradually changes in composition and concentration and is converted into urine.

The elimination of urine is partly under the control of nervous system and is partly voluntary.

Maintenance of Constant Internal Environment

We usually refer to our surrounding as our environment. The physical features of environment are light and darkness, heat and cold, wind and rain. There is sea water containing various dissolved substances and soils with various kinds of chemicals. There are also various kinds of animals surrounding man and he adjusts himself in a variety of ways to his external environment and its changes.

There is another environment inside our bodies and that is the internal environment. The various internal organs work inside our body. The tissues that constitute these internal organs are in contact with blood. Blood has certain properties. Many substances constantly enter into the blood. For example, the digested food materials and water are absorbed into the blood, oxygen is absorbed into and carbon dioxide is given out of the blood, various hormones are thrown into the blood, the excretory products of different kinds are discharged into the blood. But with all this the nature of the blood

does not change very much. It is kept more or less constant at all times. To keep the internal environment constant many organs work Lungs, kidneys, skin and liver are the organs that are responsible to a great extent in keeping the internal environment constant. The internal environment is affected if any one of the above mentioned organs does not function properly. Medicine or surgery is called for to set right the organs and to restore the normal internal environment. In severe cases of disorder the constancy might not be recovered and the organism loses its life. Thus the constancy of the internal environment is a necessary condition for normal life.

Summary

Metabolism is the sum total of all the chemical changes that take place in an organism. It is made up of two distinct processes: (i) the building up process known as anabolism and (ii) the breaking down process called catabolism.

Various kinds of enzymes play important roles in metabolism.

The end products of the digestion of fats, proteins and carbohydrates are distributed to the various tissues. There, they are converted into the substances of the cell and form the fuel for energy. The excess of fat is stored in the cells of the fatty tissues under the skin. Excess of glucose is converted into glycogen and excess of amino acids is converted into carbohydrates and fats.

Vitamins regulate many processes. Vitamin A increases resistance to infection and preserves good vision. The B complex vitamins prevent a variety of nerve and skin disorders. Vitamin C prevents scurvy. Vitamin D prevents rickets by regulating the use of calcium and phosphorus in bone building.

The liver plays an important role in metabolism. It converts excess of glucose into glycogen and stores it; it converts excess of amino acids into carbohydrates and fats respectively and converts toxic substances into harmless ones.

The energy liberated from food substances is measured as Calories. One gram of carbohydrate or protein yields 4 Calories

while one gram of fat yields about 9 Calories. The daily Caloric requirement of a person varies from 1200-3500 according to the nature of his activities.

Chemical coordination of the body results mainly from the secretions of the endocrine or ductless glands. The secretions of the ductless glands known as hormones are directly emptied into the blood stream. They affect many of the fundamental processes of the body.

They thyroid situated at the base of the larynx regulates the general level of body activity. Its underactivity results in mental deficiency in children and produces sluggishness and fatigue in adults.

The pituitary gland is the master gland because its secretions influence the other endocrine glands. It also regulates growth. Its underactivity may result in dwarfism and overactivity in gigantism.

The pancreas has an endocrine function in addition to its digestive activity. It produces insulin, which regulates the amount of sugar in the blood.

Most of the products of respiration are removed from the blood by a filtration process in the kidneys. Another function of the kidneys is the regulation of the water content of the body, and by this they control the chemical composition of blood.

The nephron is the structural and functional unit of kidneys. The filtrate of the glomeruli in addition to the waste products contains minerals and other substances useful to the body. The unwanted excretory products are eliminated as urine.

Questions

1. (a) What do you understand by the term metabolism?
   (b) What are the two main processes that constitute metabolism ?
2. (a) How are amino acids and proteins related?
   (b) Why is it necessary for young people to include protein foods in their diet?
3. Why are enzymes called organic catalysts?.

4. (a) What are vitamins?
   (b) What is the principal function of vitamin A ?
   (c) What disease is caused by the deficiency of vitamin C ?
   (d) What effect does lack of vitamin D have upon the body ?
5. How does the liver regulate the glucose level of the blood ?
6. Define a Calorie. Why does the daily caloric requirement vary among different persons ?
7. 'A diet consisting of bread, potatoes, rice, and sugar alone is not desirable though it would supply the daily caloric requirements'. Why ?
8. What are glands ? What are the two main types ?
9. Compare the effect of an overactive pituitary gland with an underactive one ?
10. What is the effect of severe insulin deficiency ?
11. Name four organs that remove waste products from our body.
12. The kidneys are sometimes called 'the regulators of our internal environment'. Why ?

Tasks

1. Prepare lists of various food materials containing vitamins A,B,C, and D.
2. Prepare an illustrative chart to show the daily caloric requirements of people engaged in different kinds of activities.
3. Study the positions and external structures of the various endocrine organs in a rabbit.
4. Examine a sheep's kidney cut lengthwise.
5. Study the urinary organs in either a rat or a rabbit.

CHAPTER VIII

The Skin

Our body is covered by a thin layer called skin. It is sometimes considered as one of the systems of our body—integumentary system.

Structure of Skin

The skin is made up of two principal layers : the epidermis and the dermis (Fig. 8.1).

Epidermis

The upper layer of the skin is known as the **epidermis.** It is made up of several layers of cells. The bottom layer of epidermis is made up of a row of flat cells, packed closely together. The cells of this layer grow and multiply unceasingly. The upper layers of the epidermis degenerate and die and new cells from below take their place.

The outermost layer of the skin is made up of dead cells. It needs no blood supply and does not get infected as long as it remains unbroken. The lower part of the epidermis is active and living. and is supplied with blood. The cells in this layer contain the pigment which gives the skin its colour. The darker the skin, the greater is the amount of this pigment. The pigment cells produce more pigments if the skin is exposed to sun.

Dermis

The **dermis** is the lower thick layer which makes the skin strong and elastic. The dermis is richly supplied with blood and lymph vessels. The nerve endings, the roots of hairs, oil glands and sweat glands are also found in this part of the skin.

A oil gland is a small sac-like structure. It secretes oil which forms a thin layer on the skin and the hair. The oil keeps the skin soft to touch and prevents excessive absorption or loss of water over the surface of the body.

A sweat gland is a coiled tube

ending in a knot. It is situated deep in the dermis. The cells of this gland collect fluid from the blood. This fluid is the sweat which is poured into tiny canals that lead to the skin surface and open

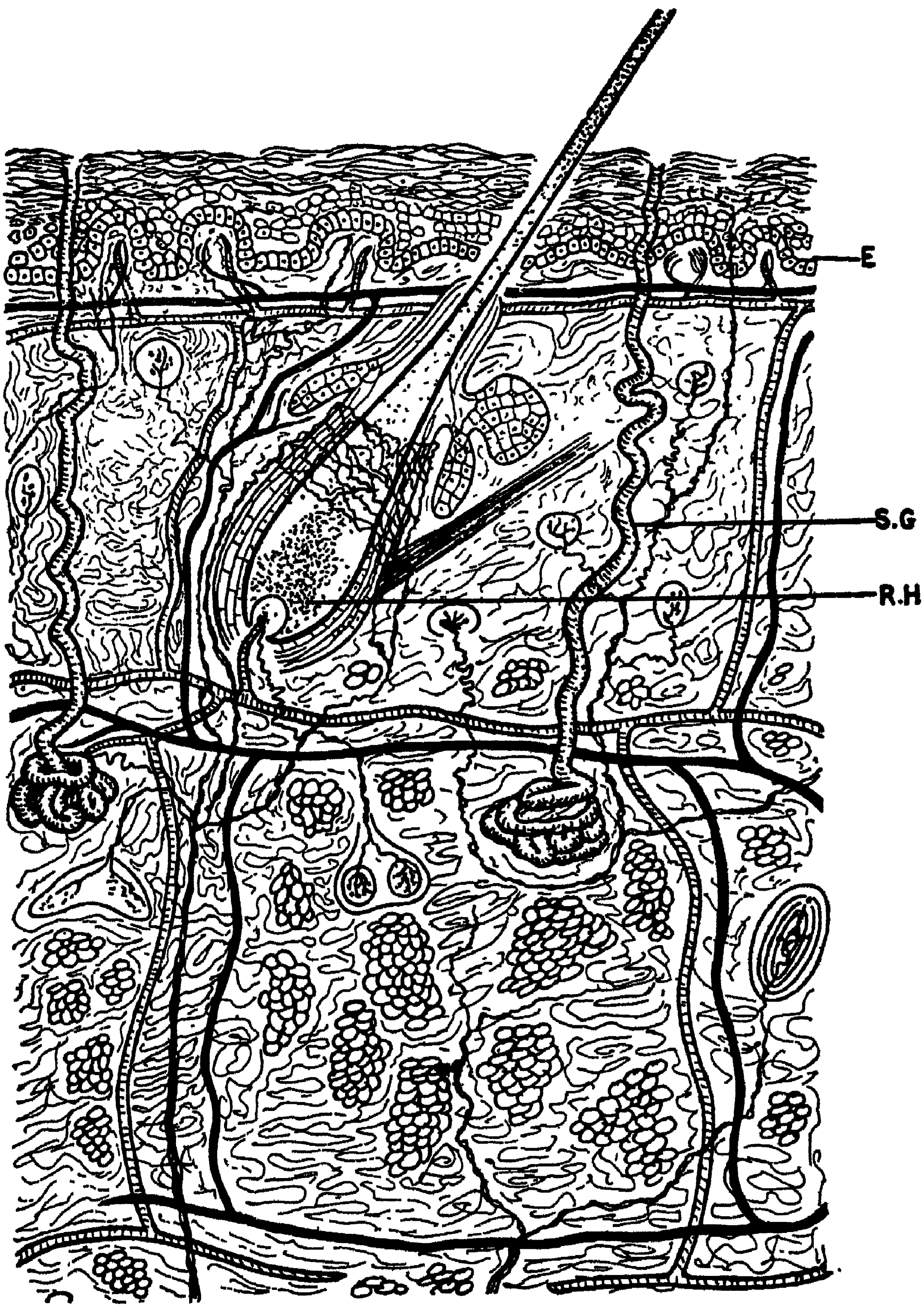


Fig. 8.1 Structure of skin : E. Epidermis ; S.G. Sweat glands ; R.H. Root of hair

through pores. The sweat consists of water, salts, a small amount of urea and certain other products. The salty taste of sweat is due to the presence of salts especially sodium chloride.

The hair is formed by the cells which line a pocket known as **hair follicle.** As the hair grows in the follicle, it is pushed upwards.

The nerve-ends in the skin carry sensations of touch, pain, pressure, heat and cold.

Subcutaneous Fatty Tissue

The fatty tissue beneath the dermis is several centimetres in thickness in certain parts of the body. This tissue is called the **subcutaneous fatty tissue.** It acts as an insulator against heat and cold. It also acts a cushion against shock. It is the place where the excess of fat is chiefly accumulated. As the body ages, fat is absorbed from the subcutaneous layer and the skin shrinks unevenly, causing the wrinkles of old age.

Functions of the Skin

Protection

The compact layers of dead cells of the epidermis protect the layers of living cells underneath it. Otherwise the living cells would be injured at the slightest contact with objects. The outer layers of the skin also keep away the microbes from entering the body and causing damage to internal tissues.

The energy of the sun's rays stimulate the living cells and increase their activity. However, too great an exposure to sun's rays might cause damage to the cells and might even destroy them. The skin produces pigments which screen off the inner tissues from the harmful effects of the rays.

The compact horny layer of the epidermis is coated with oil. This oil is impermeable to water and to a number of substances that might be harmful to the body if they were to penetrate into it. Only very few substances can dissolve the oil of the skin and enter into the body.

Role of Skin in Metabolism

The skin gives off water, salts and other products in the form of sweat. It helps the body to maintain its water balance by eliminating or conserving water. The skin, stimulated by light produces vitamin D essential in the formation of bones and teeth.

Skin as a Sense Organ

The skin helps to perceive sensa-

tions of touchs, pressure, pain, heat and cold.

Maintenance of Constant Temperature

The normal temperature of the body of a person is about 98·6° F or 37°C. This temperature is kept constant at all times of the year and in all kinds of weather. As a result of hard, strenous muscular activity great amount of heat is produced in the body. But the body never gets overheated by its own heat because the excess of heat is constantly lost from the surface of the skin through radiation. How is this done ?

You have learnt that the skin is richly supplied with blood vessels. When the temperature of the surrounding air rises, the blood vessels of the skin dilate and get filled with more blood. The extra blood heats the skin. This heat is also got rid off. In addition to this the formation of plenty of sweat during hot weather further helps to take off the heat from the body. Evaporation of the sweat causes the body to cool and thus the temperature is brought down. When the temperature of the surrounding air falls, the blood vessels constrict, very little amount of sweat is formed and the loss of heat through the skin is reduced.

Hygiene of the Skin

The oil and sweat released on the skin, if allowed to accumulate, become sticky and catch dust. The dust might close up the oil glands and interfere with further sweating. Different kinds of microbes stick to the skin with the dust particles and reproduce rapidly. Certain parasites like mites and ticks find a good hiding place on a dirty skin and cause diseases like itch. A dirty skin often carries eggs of intestinal worms.

Washing with warm water and soap is best for keeping the skin clean and healthy. The soap removes the oily layer along with the trapped bacteria. It also removes many of the outer dead epidermal cells and makes the skin appear clean.

Clothes

The underclothing quickly absorbs sweat and oil secreted by the skin. If they are used for a number of days, it becomes a good place for the bacteria to thrive. Therefore, underclothings should be changed quite often and washed

with soap. Soft material should be used for the underwear so that it might not irritate the skin.

Clothing helps our body in maintaining a constant temperature to a certain extent. Therefore the appropriate type of cloth should be used during different seasons. When it is cold, clothing should diminish the loss of heat. Therefore the best materials for winter clothing are those that are porous, as the air in the pores is a poor conductor of heat and does not allow much heat to be given up from the skin. When there are many layers of clothing with air spaces between layers the heat is given up more slowly. Dark coloured clothing helps to absorb heat quickly. During hot days, the temperature of the air is high. The clothing should help the body to give up its heat. Therefore summer clothing should be light in weight and as thin as possible, and light coloured.

Sun Stroke

Though our body has the capacity to regulate the loss of heat through its skin, it has its own limitations at times. When there is no wind and the air is hot and moist, the loss of heat is greatly diminished. A a result the body may become overheated. This overheating is known as sun stroke and this may cause death.

The chief symptoms of sun stroke are severe headache, nausea, and in some cases, loss of consciousesness and convulsions. A patient who has sun stroke should be removed at once to a cool spot and some ice or a towel soaked in cold water should be put on his head. He should be fanned so that the motion of the air will increase the evaporation of sweat. He should be given plenty of water to drink to increase perspiration.

First Aid for Burns

The skin is subjected to a variety of injuries—cuts and burns being the most common. First aid for simple cut is to clean the wound with mild antiseptic and cover it with sterile dressing.

In case of burns, if it is mild with an unbroken skin, ointment may be applied and the portion covered with a piece of clean cloth. If there are blisters, they should not be opened. The enclosed fluid helps to heal the burn quickly. The area may be covered with sterile gauze. The extreme kind of burn should be treated by physicians. The burned area may, however, be lightly covered with moistened sterile cloth, till the doctors attend to it.

Summary

Skin forms the outer covering of our body. It is made up of two layers—epidermis and dermis. The outermost part of the epidermis consists of layers of dead, horny cells. As these are worn out, they are replaced by inner layers of epidermis. The colour of skin is due to a pigment contained in the epidermal cells. The dermis is richly supplied with blood vessels. There are oil glands, sweat glands, nerve endings, and roots of hair present in the dermis. Beneath the dermis fat gets accumulated.

The skin functions in various ways. It

(a) covers the body as a protective layer,
(b) prevents bacteria from entering the body,
(c) regulates heat,
(d) eliminates water, salts and other waste products from the body through perspiration,
(e) regulates water balance in the body,
(f) feels sensations of cold, heat, pain, pressure and touch and
(g) synthesizes vitamin D.

Dirty skin and dirty clothes are ideal places for bacteria to thrive. Heavy woollen clothing during winter and light cotton clothing during summer help in the maintenance of constant body temperature.

Questions

1. Discuss the various functions of the skin.
2. How does the skin help our body in maintaining its constant temperature?
3. What glands are found in the dermis of the skin ?
4. What first aid would you give for, (a) burns, (b) sun stroke?

Tasks

Study the structure of skin with the help of a chart.

CHAPTER IX

Nervous System and Sense Organs

The functioning of our body requires the coordination of millions of cells. The nervous system plays an important role in coordinating the work of the different parts of the body. Even simple acts such as walking and running require coordination to a very great degree. In such acts, a number of muscles work together and the heart beat and breathing rate are well adjusted. Thus the coordination involves two categories of activities. One is the functioning of the internal organs. The heart beats without failure. It must beat faster or slower according to circumstances. Breathing goes on for all the twenty-four hours. The digestive tract converts complex food into simple substances and absorbs them. The kidneys and skin must function to maintain the normal composition of the blood by eliminating wastes.

The second activity in coordination is that connected with receiving and interpreting information from outside the body. The eyes receive visual signals which are sent to the brain for interpretation. The ear receives the sound waves. The information received from the sense organs determine our reaction.

Thus, in short, the nervous system is concerned with two important functions. It regulates the internal environment of our body through its control of the internal organs. It responds to the external environment through the various sense organs.

The Nervous System and its Role

The nervous system of all vertebrates including man can be divided into (i) the central nervous system and (ii) the peripheral nervous system (Fig. 9.1). The central nervous system includes the brain and the spinal cord. The peripheral nervous system includes the various nerves that are given off from the brain and the spinal cord. It includes a chain

of nerve thickenings and connecting nerves. It controls all the processes of the internal organs. Such as the heart beat, breathing, the secretion of the glands etc.

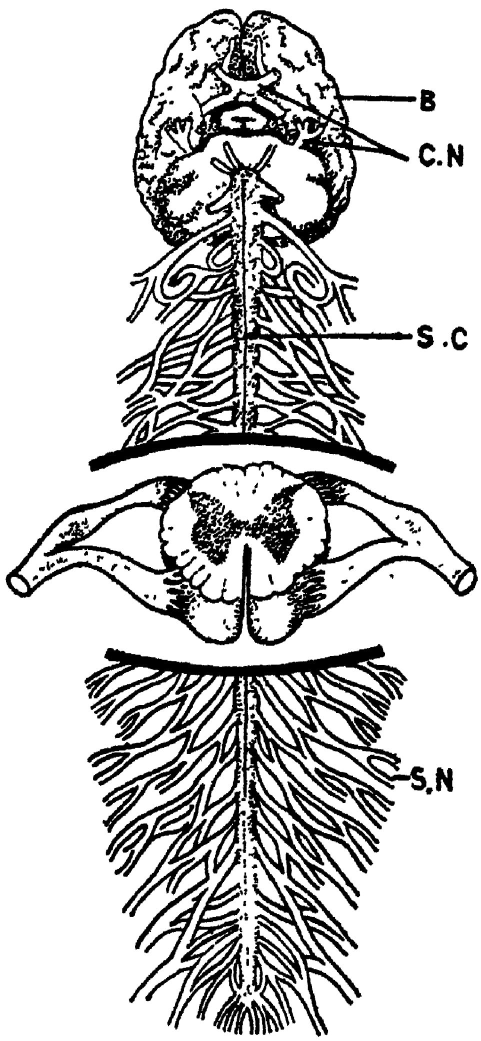


Fig. 9.1 Nervous system of man : B.Brain C.N. Cranial nerves; S.C. Spinal cord ; S.N. Spinal nerves

The Structure of a Nerve Cell

The nervous system is composed of nerve cells or neurons.

Each neuron consists of a cell body, short branching projections or dendrites and one long projection or axon. The axon enclosed in a sheath is referred to as the nerve fibre.

A nerve is a bundle of neurons surrounded and protected by a tough layer of connective tissue. Nerve cells have no direct connection with one another. A small gap exists between the axon of one neuron and the dendrites of the next one. This gap is called a synapse.

Nerve Impulse

The chief characteristic of the nervous tissue is the conduction of impulses. If a muscle together with the nerve supplying it, is cut out of the body of a frog and a stimulus like an electric current or a chemical substance is applied to the nerve, the muscle contracts. This occurs because the impulse started in the nerve travels along it and is transmitted to the muscle fibres. However, if the nerve is deadened at any point with alcohol or chloroform, impulses will not be transmitted through the dead parts.

All nervous activity depends on nerve impulses. The exact nature of the nerve impulse is not known. An impulse is electrical and it is also chemical. A nerve is a path way of impulses. A nerve impulse is conducted along a nerve at the

rate of about 20 to 30 metres a second ; in the human being the rate of conduction may rise as high as 100 or 120 metres. Nerve impulses pass from one neuron to another across a synapse.

An impulse crosses a synapse more slowly than it travels along the axon.

Spinal Cord

The brain is continued down as a long cord. The cord is located in the vertebral canal formed by the discs and arches of the vertebrae. In the centre of the spinal cord, there is a canal which runs up into the brain. This canal is filled with a liquid similar to lymph. The spinal cord is surrounded by certain membranes. There is some fluid known as the spinal fluid between the membranes. This fluid acts as a shock absorber and provides mechanical protection for the spinal cord.

The spinal cord conducts nerve impulses from the internal organs like the skin to the nerve centres of the brain. It also receives impulses from the brain and relays them to the muscles and internal organs. The spinal cord is the centre of many of the reflex actions. All the reflex actions, connected with the activity of spinal cord are unconditioned reflexes.

Reflex Arc

Unknowingly, you might have sometimes touched some hot materials or electrical appliances that give shock; or when you were absorbed in something, your friend might have pricked your hand with a pin. On these occasions how did you react? You immediately withdrew your hand. All this happened in a fraction of a second. Only after you had withdrawn your finger you felt the pain. Such kinds of reactions are called reflex actions. It consists of two aspects. The first is sensory in which a person touches something hot. The second is motor, in which he jerks his hand away.

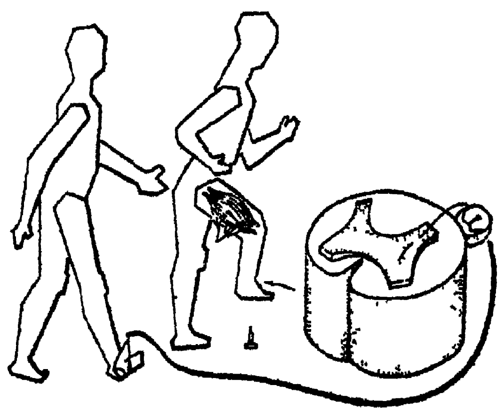


Fig. 9 .2. Reflex action

The path along which impulses that arouse a reflex action travel is called **reflex arc**. The endings or receptors of the sensory neuron pick up the pain sensation and transmit it to the spinal cord, an associative neuron picks up the message

and transmits it to a motor neuron The impulse travels over the axon of the motor neuron to the muscle and signals it to contract. Then the muscle contracts and the hand is withdrawn.

In many coordination acts the signal comes from the brain. It might take slightly longer time for the message to be received by the brain and the proper response sent from there. In case of reflex actions the messages reach the spinal cord and are not sent to the brain. The spinal cord sends the proper signal appropriate for the act. Such kinds of responses to stimuli given solely by the spinal cord without the brain participating in it are the reflex actions.

Brain—Structure and its Functions

The brain consists of .several parts viz. medulla oblongata, cerebellum and cerebrum (Fig. 9·3).

Medulla Oblongata

The upper part of the spinal cord, extending into the brain is known as **medulla oblongata**. The medulla oblongata is a centre of control of many of the vital functions of our body. The automatic regulation of the entire digestive canal, the control of breathing and the beating of the heart are all functions of this region.

Cerebellum

Behind the medulla there is the **cerebellum** which is sometimes called the "little brain". The cerebellum coordinates the movement of the muscles of the body. If the cerebellum is injured there is a lack of orderliness and exactness in movements. After the cerebellum is removed from a dog, its movements become clumsy and are made with great difficulty. It is unable to approach the point of destination in a straight line, because all preciseness in the contraction of separate muscles has

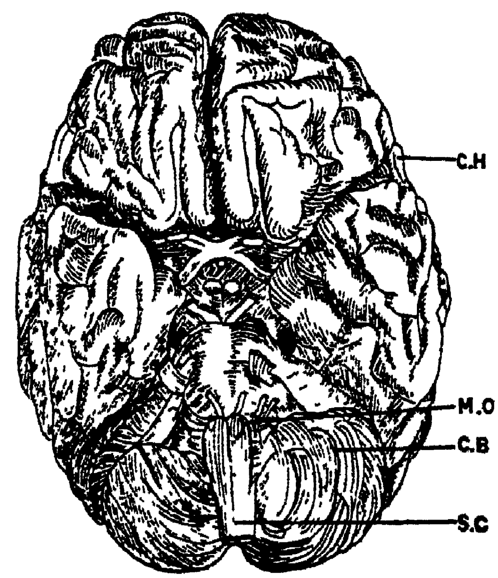


Fig. 9.3 Brain: C.H.. Cerebral hemisphere: S.C. Spinal cord; M.O. Medulla oblongata

disappeared. Such a dog is unable to seize at once a piece of meat lying on the floor. It drops its head many times in vain attempts to grasp at the food.

The cerebellum receives the impulses from the various organs like the skin, eyes, ears. All these impulses that are received are coordinated so that the muscles of the body function in perfect harmony.

Cerebrum

The **cerebrum** is the largest part of the brain in man and most mammals. The cerebrum consists of distinct right and left halves, the cerebral hemispheres. which are joined in the centre by a bridge of nerve tissue. The surface of hemispheres in human beings is marked by deep broad ridges and shallow grooves.

On the surface of the hemispheres there are fissures and between them elevations called **convolutions.** The cerebral hemispheres consist of grey and white matter. The grey matter forms the outer layer 2-4 mm thick, called the **cerebral cortex.**

The grey matter consists of cell bodies of nerves. There are approximately 14 million nerve cells of different form, sizes and functions in the cerebral cortex. The grey matter covers the white matter which is formed of the axons for fibres of nerve cells. The fibres from the right and left sides of the body cross each other and go to the left and right side of the brain respectively. Therefore the right lobe of the cerebrum controls most of the left side of our body while the left lobe controls the right side. Each hemisphere is divided into some lobes separated from one another by deep fissures.

All parts of the cerebrum look alike (Fig. 9·4). But doctors have found that injury or disease in a certain area causes defect in the nervous activity of a particular kind. Thus one area is concerned with

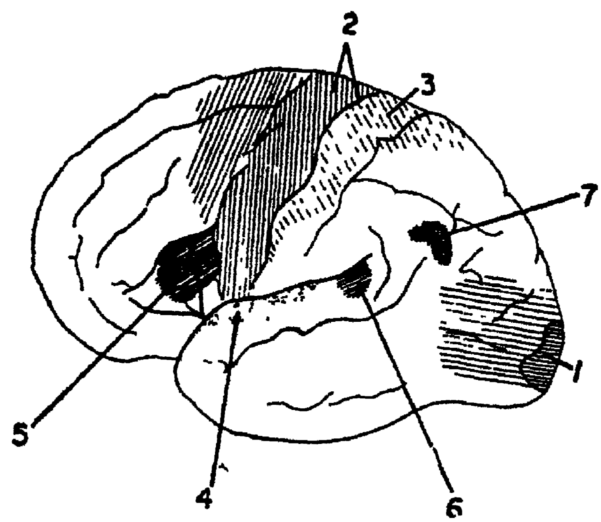


Fig. 9.4 Different areas of the cerebrum : 1. Centre of vision ; 2. Motor center , 3. center for tactile sensitivity ; 4. Center for hearing ; 5. Motor centre for speech ; 6. Auditory center for speech ; 7. Visual center for speech.

vision, another with hearing and still another with sense of smell. These specialized areas fall into distinct groups. Sensory areas receive impulses from the sense organs. They interpret them into sight, hearing, smell, taste and skin sensations. Motor areas control the muscles. Speech areas combine seeing and hearing with speaking and writing.

The cerebral cortex is the seat of memory, reasoning and will. Thus all the higher mental processes come under its control. It is cerebral cortex that has enabled man to develop a written and spoken language and thus elevated him to a level above that of all other animals.

These various areas do not function independently of each other. They all function in a co-ordinated way. The cerebral cortex with which the conditioned reflexes are connected adopt the work of organs to the constantly changing conditions of the environment.

The Brain of Man and that of Other Animals

If we compare the brains of various vertebrates including those of the human being, we will find many similarities in their structure. All vertebrates possess the main divisions of the brain : medulla oblongata, cerebellum and cerebrum. But there are also many differences between different kinds of vertebrates (Fig. 9.5). In the lower vertebrates like the fishes and frogs the hind and middle part of the brains are well developed. The fore brain is of no real significance in regulating the activity of the organism. Higher and somewhat complex nervous activity, connected with the fore-brain is found in reptiles. This becomes more complex in birds. The highly developed forebrain of mammals differentiates them from other vertebrates lower down in the animal ladder. In mammals the higher form of nervous activity is the result of the development of the cortex of the cerebral hemispheres. The cortex of man is the most highly developed of all animals. The numerous folds of the cortex greatly increase its surface area. If all folds were spread out flat, the human cortex would occupy an area almost equal to 2000 sq. cm. This is all the more striking when we consider that the brain surface of such a large animal as the horse is only 350 sq. cm.

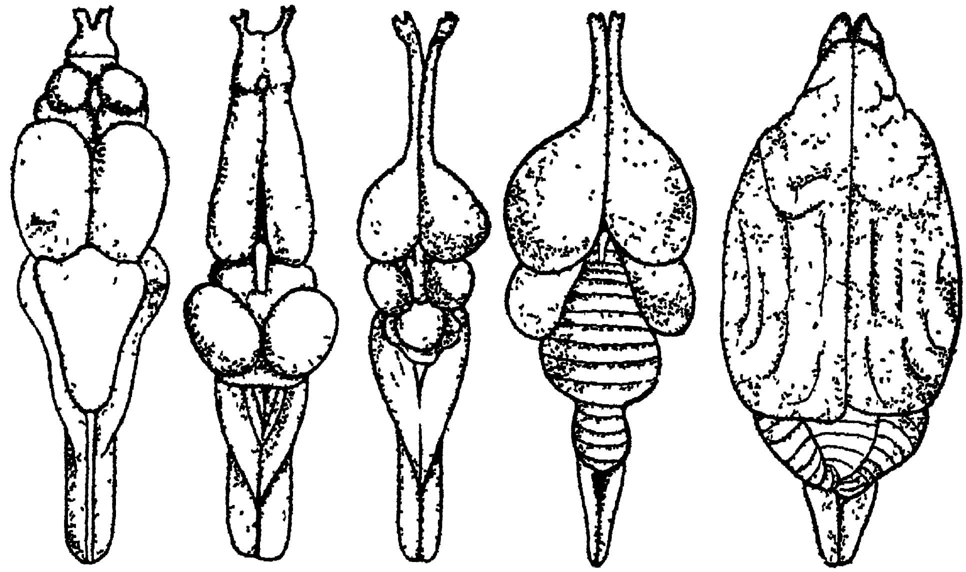


Fig. 9.5 Brains of different vertebrates

Some people think, that greater the size of the brain in a person the more intelligent he would be. This is not correct. It has been found that some stupid people had larger brains than a genius like Newton. Therefore, intelligence does not depend on brain size. It is one thing that has not so far been properly understood.

Nerves

Nerves are of two types. They are the spinal nerves and the cranial nerves. The nerves arising from the brain are called **cranial nerves.** There are 12 pairs of cranial nerves in our body. Excepting one cranial nerve, the branches of which go to the heart, lungs and other abdominal organs, the others function in the head and neck areas. You have already seen that there are 31 spinal nerves.

Conditioned Responses

If some meat is placed on the tongue of a pup that was never fed before with meat, it will salivate When a dog is given an electric shock on its leg, it will withdraw it. These are examples of inborn reflexes. They can otherwise be called unconditioned responses. Animals with the cortex of the brain removed, produce these responses. The cortex of the brain does not appear to be needed for producing the unconditioned responses.

A dog salivates at the mere

sight of food. This is also a response. But this differs from the response produced when the same food is placed on its tongue. A pup that has never tasted meat before will not salivate at the mere sight of meat. The response at the sight of meat will appear after the pup has been fed with the meat.

Such responses are not inborn. They are acquired and are continually being produced during the life of the animal. They are known as conditioned responses since certain specific conditions are necessary for their formation.

The Russian physiologist Ivan Pavlov, did pioneering work in the field of conditioned responses. When he showed food to his experimental dog, he found it salivating. He tried ringing a bell but it did not make the dog salivate. Then he rang the bell and within a few seconds of ringing he presented the dog with food. After a number of trials the bell was rung without food being presented and the saliva began to flow. Thus the ringing of a bell, seemingly in no way related to the flow of saliva, was able to produce it (Fig. 9 .6). The dog has been conditioned by the experiments. Its salivation in response to the bell is one of the examples of conditioned response. Conditioned responses play an important role in human behaviour, and in the responses of other animals. The study of conditioned response throw light on the understanding of higher mental activities.

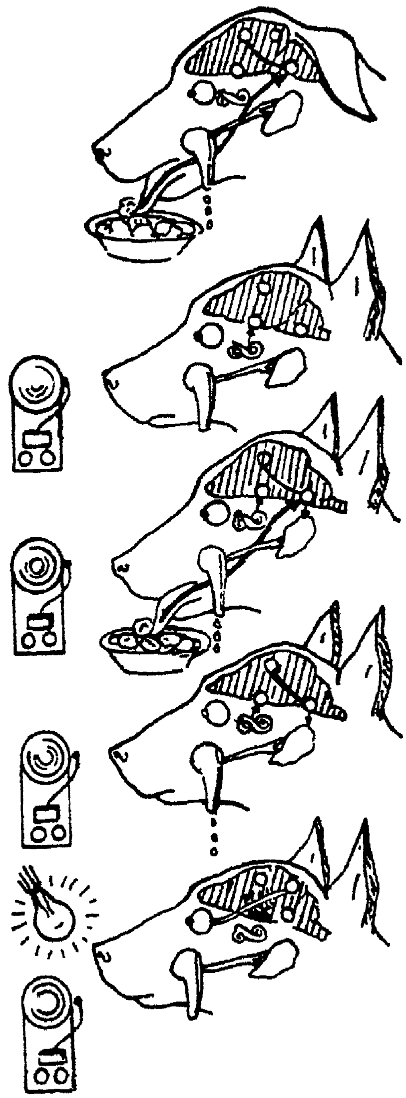


Fig. 9 .6 Conditioned response

The sense organs receive stimuli and pass the message to the brain, and the brain interprets the message. Five different senses are commonly recognized. They are sight, hearing, smell, taste and touch.

Eye

The eyes are the organs of sight. Each eye is a small ball set in a socket in the skull (Fig. 9.7). Muscles move the eyes in different directions. The eyes have many accessory parts that are primarily for giving protection to them. The eyebrows protect the eye from small particles that fall from above the eye. The hair of the eyebrows help to shade the eyes from bright illumination. The eyelids are folds of skin which protect the eye and keep them moist. The lining of the eyeball is a membrane, the **conjunctiva**. The same membrane covers the front of the eye-ball. Within the sockets, in the outer corners of the eyes are the

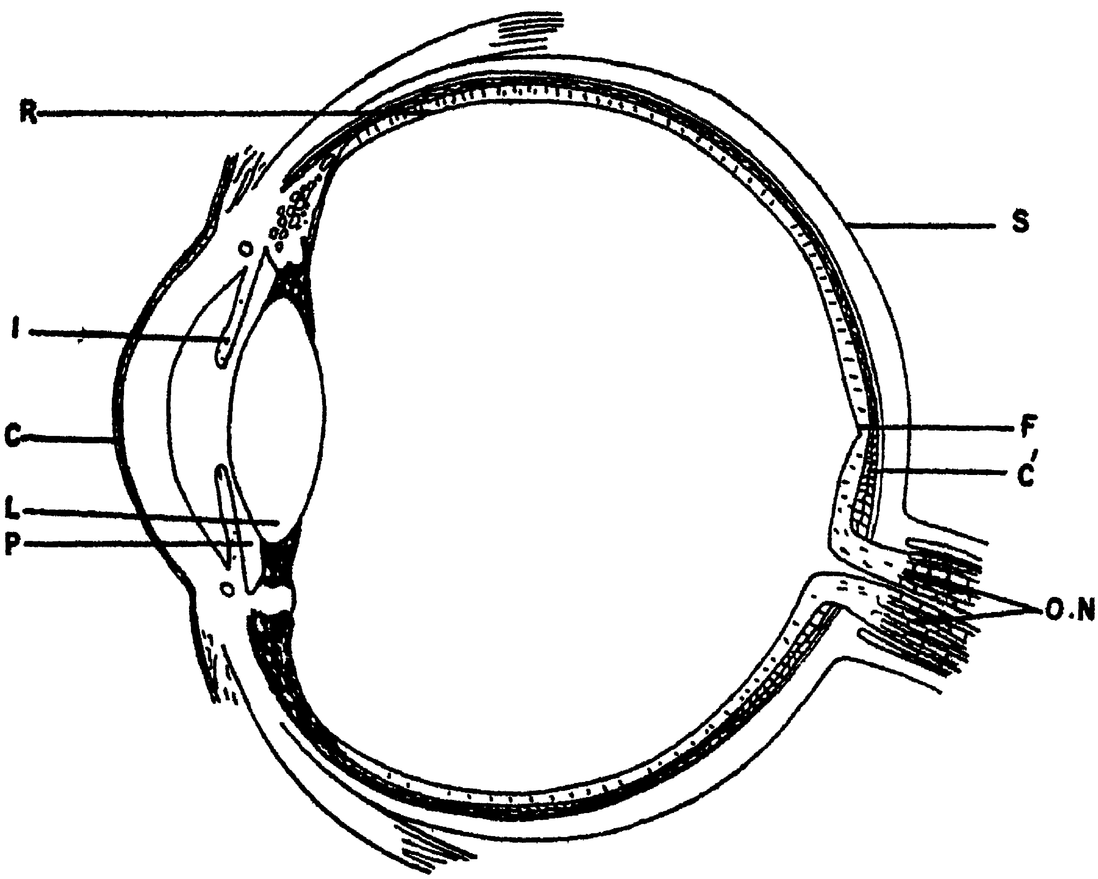


Fig. 9.7 Structure of human eye ; R. Retina : I. Iris ; C. Cornea ; L. Lens: S. Sclera ; C'. Choroid ; O.N. Optic nerve ; F. Fovea

tear glands. The liquid secreted by these glands, the tears, washes over the eyes. It keeps the eyeballs moist and washes out dirt and other foreign particles. It contains salt and is slightly antiseptic. Thus it helps to reduce the danger of eye infections. The excess tears pass off through the ducts into the nose cavity.

The interior of the eyeball is filled with a transparent jelly like substance. The wall of the eye is made up of three layers. The white of the eye is a tough outer coat, the **sclera.** The sclera covers all of the eyeball excepting the circular portion in front. The circular part is covered by a clear transparent tissue, the **cornea.** Inner to the sclera is a second layer of the eyeball, the **choroid** layer. It is richly supplied with blood vessels bringing nourishment to the eye. Cells filled with a black pigment are located on the inner surface of this coat and this pigment makes the wall of the eye impermeable to light.

The circular coloured area behind the cornea is the **iris.** The iris contains a large amount of pigment which gives the eyes their various colours. This pigment keeps light from entering the eye except through the opening in the iris. The opening in the iris is the **pupil.** The iris has two sets of muscles which regulates the pupil and the entry of light through it. One set of muscles pulls away from the pupil and dilates it. This happens in dim light. The other set is arranged in a circle around the pupil. When these muscles contract, the pupil constricts. This happens in bright light.

The lens which is a transparent double convex one, lies behind the pupil. With the help of the ciliary muscles the lens can be either flattened or made more concave. The lens is flattened to focus distant objects and made convex to focus nearer ones. Between the cornea and the lens there is a space filled with a watery fluid.

The third and the inner most coat of the eyeball is the **retina.**

From the brain, a large optic nerve penetrates into each eyeball at its back. This nerve spreads out to form a thin inner layer on the eyeball. This nerve sheet is the retina. It contains numerous nerve fibres and receptors. The receptors convert the visual light into impulses. These receptors are called **rods** and **cones** because of the appearance. The rods are more numerous in the retina than the cones. The cones of a human being are responsible for colour vision while the rods are concerned with light and

darkness. The cones have comparatively little sensitivity and therefore cease functioning at dusk or dull light. Therefore, a person cannot distinguish colours in the dull light. The rods on the other hand, possess a high degree of sensitivity.

An insufficient quantity of certain vitamins in food and also other things may cause a disease called **night blindness.** This disease destroys the functions of the rods. Therefore when there is bright light, the sight remains normal, but when it begins to get dark, a person suffering from this disease sees nothing.

The Blind Spot

The point where the optic nerve leaves the retina is devoid of any of the light sensitive cells. The spot is called 'blind spot'. The images falling on this spot cannot be seen. The blind spot can be easily located the means of simple a experiment (Fig. 9.8). Close your left eye and look steadily with the right one at the cross on the left side of

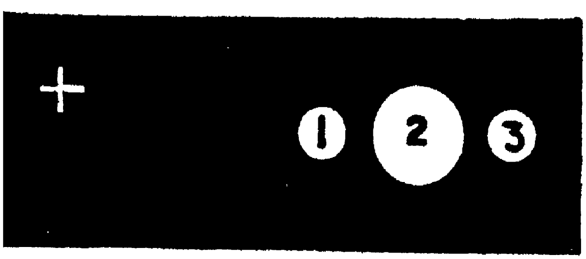


Fig. 9.8 How to locate blind spot in the eye

the figure, holding the book 15 cm away from the eye. Now move the book slowly away from you. At first the small circle nearest to the cross will disappear ; then the large circle will become invisible and finally the third.

Visual Sensation

The light rays entering through the transparent cornea and passing through the watery fluid, the lens and the jelly like substance, fall pon the retina. An image forms on the retina. In passing through the lens the rays from different parts of the object are crossed and the result is the image formed on the retina is an inverted one. The image thus formed is converted into impulses by the rods and cones and sent to the brain. The brain cells in the sight region has the capacity to invert the figure and interpret what we see.

Long and Short Sightedness

When the light rays enter through the lens, the curvature of the lens is altered to focus it correctly on the retina. When the lens is unable to focus the light rays on the retina, common vision defects like the long and short sightedness result.

In long sightedness, the light

rays are focussed at some point behind the retina. The condition is caused either due to the shortened shape of the eyeball or by loss of ability of the lens to change shape for near vision. In children the long-sightedness is due to the shortened form of eyeball. In adults it is due to changes in the lens and lens muscles. As a person gets aged see clearly objects from distances but it is difficult for themto see clearly objects that are very close. This defect can be rectified by wearing glasses with double convex lens. The condition in aged person becomes worse with the passing of years. Therefore they should have their eyes examined every two or three years.

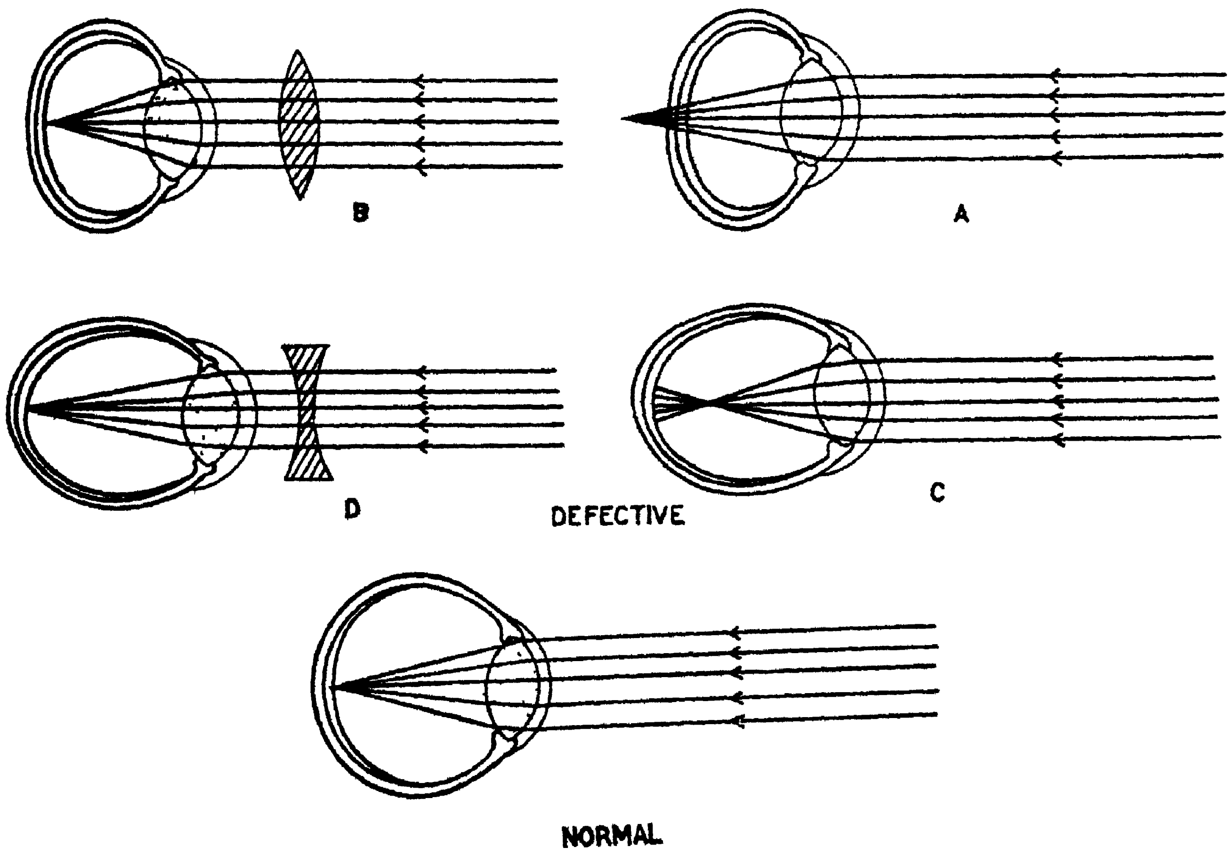


Fig. 9.9 Long sightedness ; A and B. Convex lens corrects a far sighted eye; C and D. Concave lens corrects a near sighted eye

the lens become rigid and flattened out. The muscles try hard to thicken the lens and become weak in due course. The long-sighted people can

In short sightedness the light rays get focussed in front of the retina. This happens when the eyeballs are The too long from front to back.

lens muscles cannot adjust the lens to focus the rays on the retina. In this defect the distant objects appear dim and blurred but objects very close to the eyes can be seen well. By wearing glasses with concave lens the defect can be rectified.

Hygiene of Vision

A great strain is exerted upon the eyes in reading and also when doing many kind of fine work. In order to keep the eyes healthy and to get the maximum benefit out of them, it is necessary to observe certain elementary rules of hygiene for the sight.

The room in which we work should be well lighted. A good light is one that will allow a person with normal sight to read freely a book with small print at a distance of 37-35 cm from the eyes. If the light is poor, a person is forced to bend over his work and strain his eyes very much. Sometime the light becomes poor because of the layer of dust which covers the window panes and the bulbs of lamps. Therefore it is necessary to keep all these clean. Very strong light is also harmful. Bright light irritates an eye and if the irritation continues for a long time various disorders of the eye may result.

The even distribution of light and direction and position of the light are also important. Reflected light is the best. The position of the source of light should be such that the light will not blind the eyes but will be strong enough to light up the place of work well. While writing, the light should come from the right side, so that the shadow of the hand or body does not fall on the writing material.

Correct lighting increases the the working capacity and diminishes the general fatigue of the body. Frequent and prolonged eye strain weakens the sharpness of one's sight and is the cause of short sightedness.

Sometimes the eyes get strained due to an incorrect position of the head. To avoid overstrain of the eyes one must sit erect without bending the head and the book or note book should be placed in front, in an inclined position. It is not a good practice to read while lying especially on one side.

When reading for a long time, one should stop from time to time at least for a few minutes to give rest to the eyes. If the eyes get tired frequently, it is necessary to consult a doctor and find out the defect. One should not consult quack doctors and apply all sorts of drugs to the eyes. In case of short-sightedness and far-sightedness and similar defects one should

wear glasses prescribed by doctor.

Ear

.The ears are the organs of hearing. They are responsible for converting sound waves into nerve impulses and sending them to the brain. The organ of hearing is divided into three regions ; the external, middle and the inner ear (Fig. 9 .10).

The external ear consists of two parts ; the **auricle** and the **auditory canal.** The auricle is made of cartilage covered with skin. It helps to direct the sound waves into the canal. Stretched across the inner end of the canal is a circular membrane the **eardrum** or the **tympanic membrane.**

There is a cavity beyond the eardrum and this is the middle ear. In the middle ear a chain of three bones is present. Because of their shapes these bones are called the **hamer,** the **anvil** and the **stirrup.**

In order that sound vibrations be transmitted normally it is most important that the air pressure in the middle ear should be equal to the outside atmospheric pressure. The two pressures are equalized through the **eustachian tube.** The tube is a canal which unites the cavity of the middle ear with the pharynx. The opening into the pharynx usually remains closed and opens only at the moment of swallowing

The inner ear contains three **semicircular sanals** lying in the upper part of the cavity, and the

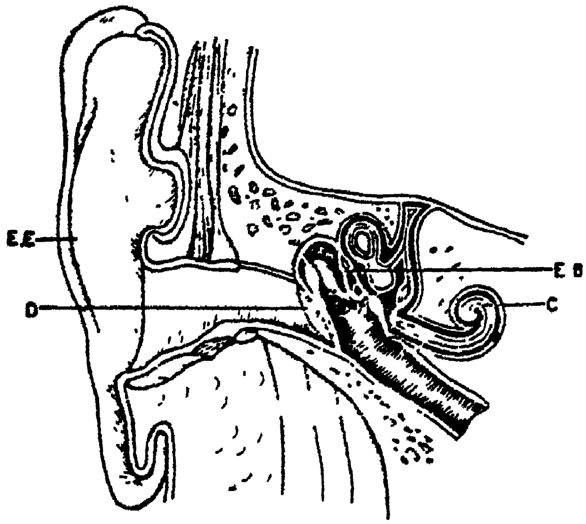


Fig. 9 .10 Structure of the ear : E.E. External ear ; D. Ear drum ; E.B. Ear-bone ; C. Cochlea

cochlea occupying most of the inner ear cavity. The semicircular canals help us to maintain balance. The cochlea is the hearing apparatus. It has a peculiar shape like that of a snail's shell. The inner ear is entirely filled with liquid. A thin membrane called **basilar membrane** lies inside the cochlea. It extends along the whole length of the canal dividing it into an upper and lower part. On the upper surface of the basilar membrane is located the spiral organ (**orgon of corti**). This organ has a complicated structure. It consists of hair like cells of

different types. It is the sound perceiving apparatus.

Hearing

The sound vibrations are directed by the outer ear to enter the auditory canal. These vibrations impinge on the eardrum and causes it to vibrate. The eardrum in turn moves the bones of the middle ear. The bones amplify the vibrations and make it possible for the human ear to hear even a faint whisper. One of the three bones, the stirrup is attached to a membrane that covers the entrance to the inner ear. Vibrations of the bones are thus transmitted to the membrane. The vibrations of the membrane are carried to the fluid which fills cochlea. The fluid in turn stimulates the hair cells. Not all hair cells are set in vibration in response to each sound, but only a certain definite portion of them. Thus the sound is converted into nerve impulses which are conducted to the brain through a nerve and we hear the sound.

Sense of Balance

The three semicircular canals located in the cavity to the inner ear are the organs of balance. Each semicircular canal stands at right angles to the other two. The canals contain fluid inside them and have abundant nerve endings Any disturbance of our position from the normal disturbs the fluid in the semicircular canals. The disturbance stimulates the nerve endings which convey the message to the brain and we feel the changed position.

Hygiene of Ear

The ear does not require so much care as an eye. Wax is normally present in the canal of the ear. Sometime the wax might get accumulated and hardened. It should not be removed by hard and sharp objects. These objects might injure the eardrum. Doctors can remove it without any pain. The ear should not be exposed to very loud sounds like the explosive sound of a bomb. Such a sound might rupture the ear drum. The ear drum can be protected by pluging the auditory canal with cotton.

Organs of Smell and Taste

The organ of smell is located in the mucous membrane of the upper part of the nose. It is made up of olfactory cells (Fig. 9.11). These are sensitive only to substances borne into the nose by the air. They cannot detect the smell of any solid or liquid substances unless the minute particles of the substances

are actually carried in the air.

Fig. 9·11 Organs of smell :
1. Sensory cells

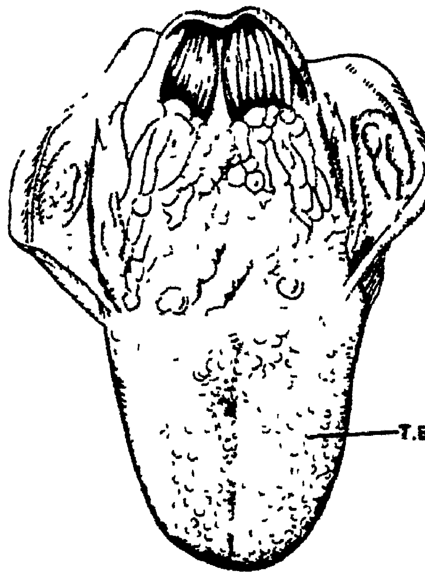


Fig. 9·12 Taste buds on the tongue :
T.B. Taste buds

On the tongue and in the back of the mouth are minute buds called taste buds (Fig. 9.12). These react to substances dissolved in water or saliva. The taste buds are found mainly towards the edge of the front side and back of the tongue. Some buds are also located on the wall of the pharynx and larynx. Taste buds distinguish

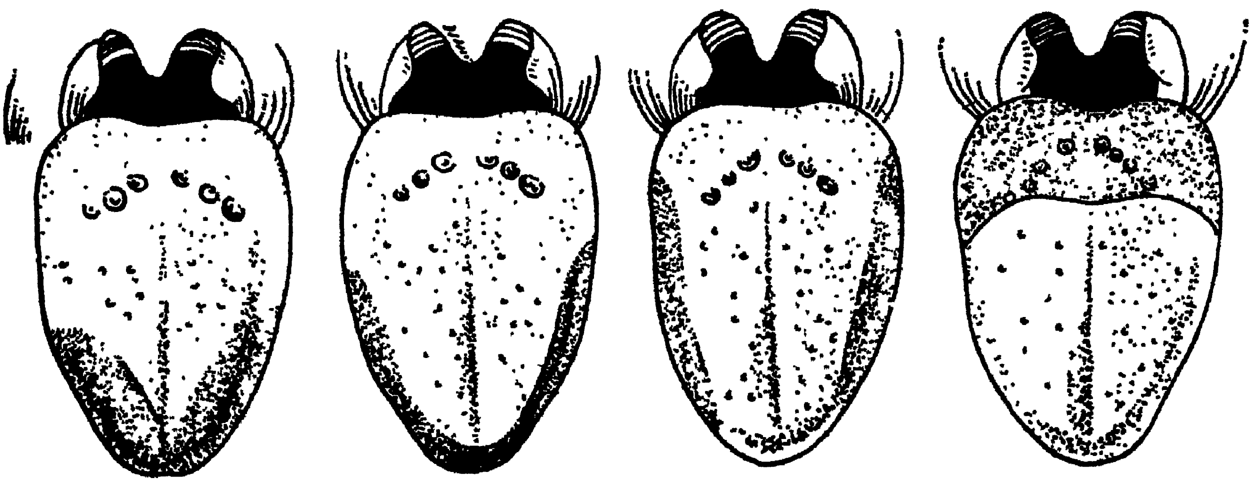


Fig. 9·13 Areas of taste on the tongue : A. Sweetness ; B. and C. Saltiness and sourness : D. Bitterness.

four primary kinds of taste : sweet, salty, bitter and sour. The taste buds for sweetness are located near the tip ; those for sourness and saltiness are found on each side and those for bitterness are localized at the back of the tongue (Fig. 9.13).

In human being, the two senses odour and taste are closely related. What we find out as the taste of a food when we eat it is actually the combination of these two senses.

Skin as an Organ for Different Sensations

Receptors of different kinds are embedded in the skin. These receptors are tiny structures. With the help of these structures we feel different sensations like touch, pressure, heat, cold and pain. The skin is not uniformly sensitive. The skin of head and face are more sensitive than that of the shoulders and back.

Summary

The nervous system coordinates the activities of the internal organs and provides us with information about our environment. The operation of the nervous system depends upon the transmission of nerve impulses by neurons or nerve cells. The central nervous system consists of the brain and the spinal cord and the nerves that lead from these organs to other organs of the body.

The spinal cord is a relay centre of the nervous tissue that brings nerve impulses to and from the higher nerve centres in the brain. It is also a centre of reflex actions. The medulla oblongata is concerned with regulating the internal body functions. The cerebellum is a part of the brain that coordinates body movements. The cerebrum is the largest part of the brain. It is the centre of memory, conscious thought and will. Special areas of the cerebral cortex have been identified with specific functions such as sight, hearing and smell. Conditioned responses are acquired during the organism's life.

The eyes send nerve impulses to the brain as a result of the action of light upon light-sensitive pigments in the rod cells and cone cells. The rod cells are active in dim light and the cone cells are active in bright light and seem to be responsible for colour vision. When the lens is unable to focus light rays on the retina, common

vision defects like the long- and short-sightedness result. These can be rectified by wearing appropriate lenses.

The ears receive sound waves. Sound vibrations move the ear drum, and these are transmitted by the bones of the middle ear to the cochlea. A fluid in the cochlea stimulates the hair cells present there to send nerve impulses to the brain. Semicircular canals in the inner ear also control the sense of balance. Taste and smell are chemical senses. Certain chemicals dissolved in water or saliva stimulate the taste buds of the mouth and throat. Chemicals in vapour state stimulate the olfactory cells of the nose. The skin contains receptors for the recognition of pressure, heat, cold and pain.

Questions

1. (a) Describe the structure of a nerve cell.
   (b) Distinguish between a dendrite and an axon.
2. (a) What is nerve impulse ?
   (b) How is it transmitted from one nerve cell to another ?
3. What do you understand by the term reflex arc ?
4. What are the principal functions of a cerebrum ?
5. What are conditioned responses ?
   What are the differences between conditioned and unconditioned responses ?
6. How is the human eye adapted for close and distant visions ?
7. How do rods and cones function in vision ?
8. (a) What are the causes for short-sightedness and long-sightedness in persons ?
   (b) How can they be rectified ?
9. What rules would you follow to keep your eyes healthy ?
10. What are the functions of the following parts in a ear ?
    (a) Eardrum
    (b) Eustachian tube
    (c) Cochlea
11. Which part of the ear is concerned with maintaining balance ? How is balance maintained ?
12. List the three bones that transmit sound waves to the inner ear.

13. List the four primary kinds of taste sensation.
14. Why are taste and odour likely to be confused ?
15. What are the different kinds of receptors found in the skin ?

Tasks

1. Study the different parts of the nervous systems of a rat or rabbit.
2. Observe what happens when the nerve of the hind-limb of frog is stimulated.
3. Observe the reflex action in a decapitated frog.
4. Study the parts of the brain of a sheep.
5. Study the parts of a dissected eye of sheep.
6. Find out the different areas of the tongue that help in distinguishing four primary kinds of taste sensations.
7. Map out the areas of pain, heat, cold and pressure senses on your skin.

Human Development and Heredity

Development

Reproductive Organs

The main reproductive organs in human beings are the two testes in the male and the two ovaries in the female. In certain characteristics the reproductive organs of human beings resemble those of other mammals.

Reproductive Cells

The two kinds of reproductive organs mentioned above produce two different kinds of reproductive cells (Fig. 10.1). Each testis is composed of numerous, highly coiled tubes. Inside these tubes male reproductive cells are produced. These cells undergo some changes and develop into sperms. Each sperm is made up of a thickened part called the head, and long thin structure its tail. The head contains the nucleus and the tail is made up of cytoplasm. The sperms

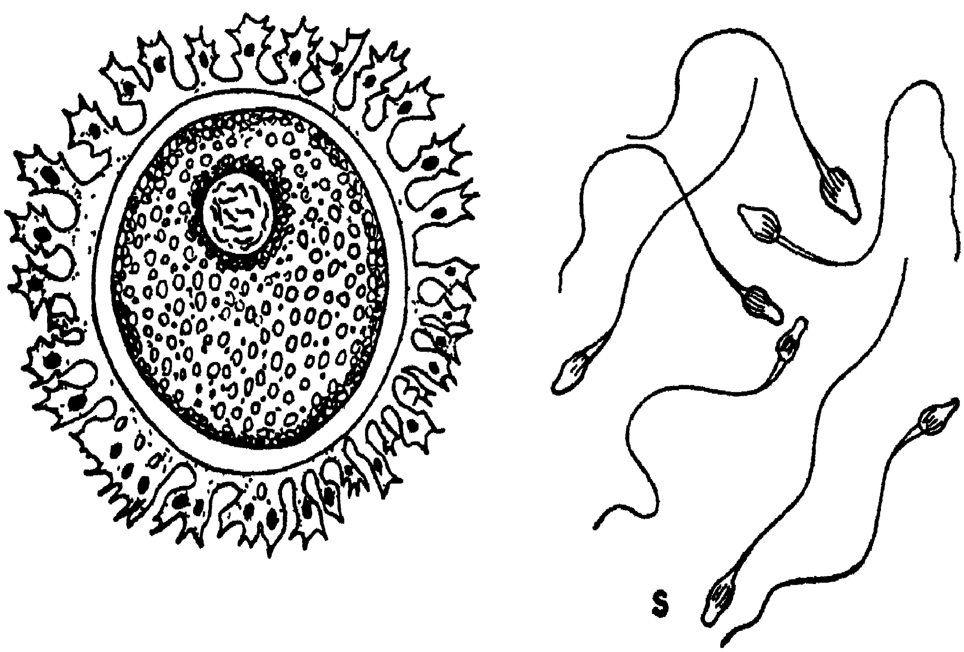


Fig. 10.1 Human ovum and sperms : S. Sperms ; O. Ovum

are highly motile. They are very small and could be seen only with the help of a microscope. The sperms remain suspended in a liquid medium and swim by the lashing movements of their tails. This liquid prevents the sperms from drying and also provide nutrition to them during their short life. The sperms and whitish liquid are together known as the **semen**.

The female sex cells are the **ova** (singular-ovum), which are produced by the ovaries. Each mature ovum, which is of the size of a pin's head, is many times larger than a sperm. The ovum like the other cells is made up of a nucleus and cytoplasm.

The ovum or egg cell contains material upon which the developing embryo is nourished in its initial stages.

The ova are released from the ovary and enter the oviducts, which are tubes extending from the ovaries to the uterus. The uterus is a thick walled chamber adopted for the development of the embryo. The semen from the male reaches the reproductive organs of the female.

Fertilization

The sperms move up and enter the oviduct where one of them comes in contact with an ovum (Fig. 10 2). The single sperm penetrates the ovum and the two cells fuse. The fusion of the two cells is **fertilization** The fertilized cell is called the **zygote**.

The zygote rapidly divides. At first it divides into two cells. These two cells divide into four and these become 16 and so on. Even when the divions are going on, the zygote moves down the oviduct and reaches the uterus. It then gets embedded inside the soft tissue of the wall of the uterus.

The zygote gets transformed into multi-cellular embryo. The number of cells in an embryo goes on increasing in number. Gradually the cells arrange themselves in three layers as they multiply. The outer layer later develops into the skin, eyes, ears and the nervous system. The middle layer forms the muscles, skeleton, kidneys, heart and blood vessels, The inner layer produces digestive system, lungs and glands.

Nutrition of the Embryo

The embryoes of animals like reptiles and birds are surrounded by plenty of yolk. The developing embryoes of these animals obtain their nourishment from the yolk (Fig. 10 3). In mammals including man the ovum contains a very minute quantity of yolk which can

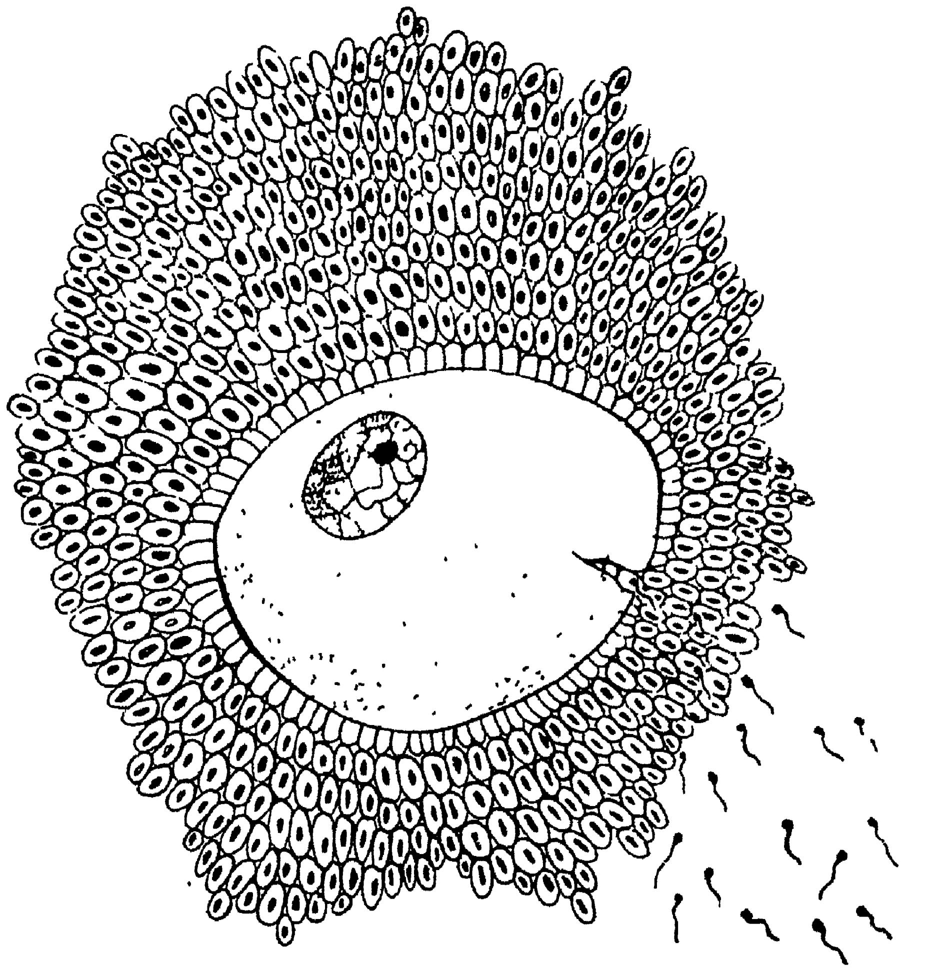


Fig. 10.2 Fertilization

nourish it only for a very short time. Therefore, the developing embryo has to depend upon its mother for its nourishment.

The embryo gets its food with the help of a structure called **placenta.** Let us see how this placenta is formed.

As soon as it gets attached to the uterus and embedded in its walls, the embryo forms certain membranes. The outermost membrane which is the first to be formed is the **chorion.** From the surface of this membrane tiny finger-like projections grow out and penetrate into the soft tissues of the uterus and fuse with it. Thus the embryo is firmly attached to the uterine wall. This attached part of the choroin and the adjacent part of the uterine tissue is the placenta.

Then a cord is formed extending from the body of the embryo to

the placenta. This cord is known as the **umbilical cord.** It contains important blood vessels that connect the developing embryo with the placenta. The heart of the embryo, by its contractions forces the blood along the arteries of the umbilical cord to the placenta. There it meets the blood capillaries from its mother's body. The two sets of vessels are separated by a thin layer of cells. Through this

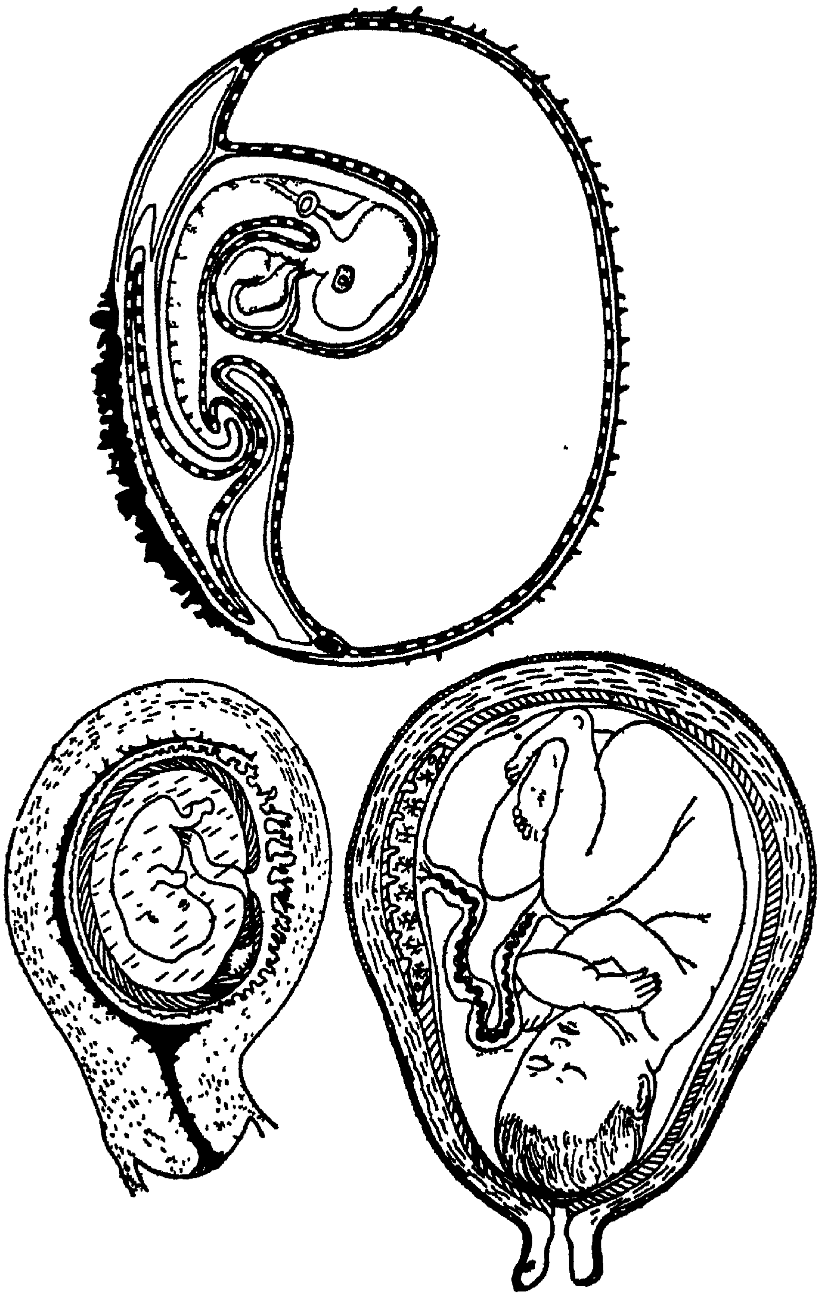


Fig. 10.3 Stages in the development of human embryo

layer they can exchange oxygen, carbon dioxide, nutrients and waste materials by diffusion. The blood brought by the arteries of the embryo frees itself of the waste products and takes in oxygen and nutritive materials. This blood is returned to the embryo through the wide vein.

Development of Foetus

The embryo continues to develop inside its mother's body for a period of about 9 months. After about 8 weeks the embryo acquires the characteristics of the body. After this stage the embryo is called a **foetus.** The foetus is already enclosed in a spacious bag-like membrane known as **amnion** The cavity formed by this membrane is filled with a fluid. The foetus is thus bathed in the fluid. This gives freedom to develop and move about. Moreover, it serves as a good shock absorber, absorbing the shocks and jolts which the mother might receive.

The foetus develops rapidly. At the time of birth it weighs about 3 kg and measures about 50 cm in length. Pregnancy lasts on the average about 9 months or 280 days in the human female. This period from fertilization to birth is called the period of **gestation.** It varies in different mammals, being 20 days in mouse and 640 days in elephants.

Birth

At the time of child birth the muscles of the uterus begin to contract and relax. This results in breaking the sac (amnion) around the body and releasing its fluid. After this, the baby is also released outside. The umbilical cord leading from the baby to the placenta is tied off and cut by the doctor or nurse. The small piece of it remaining attached to the baby shrivels and falls off in a few days. The navel indicates the place where it was once attached.

Heredity

We all know mammals including man give birth to live young ones. The young ones develop into adults and very often they resemble their parents in many aspects. What is the cause of this resemblance and what is the connection or link between individuals of one generation and those of the next? Is there anything physical that is passed on from one generation to the next? Let us try to

find answers to these questions.

In the earlier section of this chapter you have learnt that every individual starts life as a fertilized egg. The egg by repeated divisions becomes the embryo and the embryo develops into the organism. The fertilized egg is formed by the union of sperm and the egg cell. Thus the physical link between two generations is the gametes or sex cells. Whatever characteristics the parents pass on to the offspring is only through the sex cells, i.e. the sperm (from father), and the egg (from the mother). Heredity is the transmission of traits or characterstics from one generation to another.

Chromosomes and Heredity

What is it that determines the characteristics of a human individual ? It has been found out by scientists that the nuclei of the gametes are concerned with heredity. You have already learnt in your earlier classes what chromosomes are and how they are constant in number in all cells. The chromosomes have been found to contain small units called **genes**. It is these genes which actually determine or control hereditary characters.

The scientists have probed further to find out the chemical nature of the genes. They have discovered that genes are made up of a chemical substance known as nucleic acid. The one forming the genes is known as deoxyribose nucleic acid or in short DNA.

Like begets like. Dogs give birth to pups and cats to kitten and human being to babies. If a baby resembles a human being it is due to the work of the genes on chromosomes. These genes are also responsible for making a child resemble his parents or vary from them in certain features.

The nucleus of each cell of the human body has 23 pairs of chromosomes. You may recall that this human being has developed from the single cell, the zygote. The zygote itself is the product of fusion between the sperm and the egg. If there is constancy in the number of chromosomes, how can the zygote which is the product of fusion of two cells have only 46 (23 pairs) chromosomes. By a peculiar division at the time when gametes are formed each gamete, sperm or egg comes to have only 23 chromosomes. When they fuse each contributes 23 chromosomes and the zygote comes to have 46 chromosomes. It may be found that in the zygote the two members of each pair of chromosomes resemble each other in size as well as shape. It is indeed

marvellous to think that these chromosomes have enough genes in them to direct the development of this zygote into the adult.

Of the 46 chromosomes in the zygote 23 were contributed by the sperm and 23 by the egg. Thus the characters of both parents are mixed and passed on to the off-spring or the child.

Determination of Sex

If the chromosomes direct the development of an organism, do they also determine whether a zygote will develop into a boy or a girl? The answer is yes. Look at the picture of the human chromosomes in a male (Fig. 4.1). You will find 23 pairs. In every pair the two members of each pair are similar in shape and size except those in one pair. In this, one chromosome is long (X chromosome) and another is a little short with a bent end (Y chromosome). This dissimilar pair (X Y chromosomes) are called **sex chromosomes**. In the cells of the female the two chromosomes of the pair are similar to one another i.e. both are long like the X chromosomes. When gametes are formed, each sex cell gets only half the number of chromosomes that is they have only 23 chromosomes. compared to 46 in the somatic cells. During the formation of the gamete only one member of each pair of chromosomes goes into the nucleus of the gamete.

All eggs produced by a female will be alike, each will have one X chromosome. The sperms produced by a male will be of two kinds; one kind will have the X chromosome and the other the Y chromosome. The fusion of sperms with eggs takes place at random. An egg may meet a sperm with X chromosome and the resultant zygote will have the pair XX and this would develop into a girl. If an egg meets a sperm with Y chromosome the resultant zygote with X Y chromosomes will develop into a boy.

Hereditary Diseases

Certain diseases are inherited by offsprings from their parents. Scientists have found out that the genes for some of these diseases are located on the sex chromosomes and are in herited through their transmission.

One such disease is **colour blindness**. Persons suffering from colour-blindness are not able to distinguish the colours red and green. Colour blindness occurs, mostly in men. In women it is rare. Another kind of disease transmitted through sex chromosome is **haemophilia**.

Haemophilia is a condition in which the blood fails to clot or takes a long time to clot after an injury. Persons suffering from this disease often bleed to death from even a small injury. The males are the usual victims. It has a royal history. It was found in the descendants of Queen Victoria and has affected the royal families of three countries viz., Prussia, Spain and Russia. It has even affected the course of history in Russia. Luckily haemophilia is rare but is more serious than colour blindness.

A number of diseases are known to have been passed on from the parents to their children. In other words the children have inherited these diseases from their parents. All such diseases are known as hereditary diseases. Some examples of hereditary diseases are feeble-mindedness a condition in which the person remains an idiot without showing normal intelligence ; diabetes, tuberculosis, and certain forms of mental diseases.

Summary

The testes and the ovaries are the male and the female reproductory organs in the human being. These produce the sperms and the ova, both multicellular, but the ova are many times larger than the sperms. When the two fuse at fertilisation, the zygote is formed. This develops into the embryo which gets attached to the wall of the uterus. It obtains nourishment from the mother through the placenta. The embryo attains most of its gross features when it is about 8 weeks old and is then called the foetus. The gestation period for the foetus is about 280 days.

Heredity is the transmission of traits from one generation to the next and it has been established that the chromosomes carry the genes which control the hereditary characters. The genes are chemically made of deoxyribose nucleic acid (DNA). In man there are 23 pairs of chromosomes. Sex is determined by one pair of chromosomes. Colour blindness and haemophilia are defects which are transmitted through the sex chromosomes.

Questions

1. What are the common features and differences between an ovum and a sperm ?

2. (a) How is the zygote formed in the human being ?
   (b) How many chromosomes are present in a zygote ?
   (c) How many chromosomes are present in an ovum ?
   (d) Are there any differences between the chromosomes present in an ovum and a sperm ?
3. (a) What determines the sex of a baby ?
   (b) What differences do you expect in the chromosomes of a zygote that will dcvelop into a female baby and another zygote that will develop into a male baby ?
4. (a) What are genes ?
   (b) What is the chemical substance that constitutes the chromosomes.
   (c) What are the diseases for which the genes are said to be located on the sex chromosomes.
5. (a) What is placenta ?
   (b) From where does a developing foetus get its nourishment ?
   (c) How is the umbilical cord useful to the developing embryo.

Tasks

1. Examine the tests and ovaries of a rat or rabbit.
2. Examine a drop of a bull's semen under the microscope to understand the structure and movement of the sperms. (A sample of bull's semen can be obtained from a veterinary clinic or hospital and it can be examined there).
3. Study the different stages of a human embryo from a chart or model.
4. Examine the number of human chromosomes from a chart or picture in a biology book. Find out the differences between an X and a Y chromosome.
5. Prepare a short account of hereditary diseases in man.
6. Visit the museum of a hospital or a college to see a human foetus preserved.

CHAPTER XI

Human Body As An Integrated Whole

In the preceeding chapters we have learnt that the human body is made up of different systems. Man for his own convenience has isolated the different organs from the organism to study them. This does not mean that each system functions independent of others. An isolated organ differs greatly from the same organ when it is an integral part of the whole organism.

The human body is an integrated whole. Though it is made up of different systems, each system influences the work of the other systems and in turn gets influenced by them. Thus all systems depend upon one another for maintaining the normal function of the human body as a whole.

You have learnt already that the alimentary canal helps to convert the food into simpler substances so that they could be used by all the living cells of the body. After these food substances are absorbed in the intestine, the blood takes up the responsibility of distributing them to different parts of the body. If by some chance this alimentary canal ceases to digest the food materials, then all the cells of our body might ultimately be starved to death. For sometime the cells may go on functioning utilizing the nutrients already stored in them. But after sometime the growth of the cells and their normal activities may be affected. Ultimately they will not have this energy to carry out their functions and will eventually die.

You have learnt the different functions of the circulatory system. The blood in the course of its unceasing circulation, helps in the exchange of materials between it and the tissues. It carries the digested food materials and supplies them to all the living tissues of the body. It exchanges carbon dioxide for oxygen. It carries the waste products of metabolism to the excretory organs for elimination. If the movemement of blood is stopped, the cells of the body will cease to get the supply of oxygen which is so mportant in the release

of energy. The muscles that work need greater supply of blood. The signal for increased supply of blood to the muscles is given by the nervous system. The vessels supplying the blood are made to dilate and the heart works faster to send more blood to the muscles. You might remember that when you run or do manual work, you feel that your heart beats faster. You now know that it works faster only to send more blood to the muscles.

Another example will also make it clear, how coordination is brought about during infection of a muscle tissue with germs. The infected area gets swollen and becomes reddish owing to a greater supply of blood corpuscles being rushed to the spot. The corpuscles help in fighting the disease causing germs. The human body thus functions as an integrated whole structure.

Summary

The human body functions as one integrated organism. Man has isolated the organs and organ systems to study their working. But in reality the organs work in complete coordination with one another.

Questions

1. Name two systems of our body that control the activities of all other systems.
2. Explain any one phenomenon known to you in which many systems coordinate with one another.

Tasks

1. Take the pulse rate of a pupil who is lying down quietly. Compare this with the pulse rate after he has run about 100 metres.
2. Study a chart of the human body in order to understand how different organ systems are closely connected with one another.